Power System Optimizer

POLARIS SYSTEMS OPTIMIZATION

The Unrecognized Potential of Integrated System Planning

Russ Philbrick, 4/28/2025

Goal: A Broader View of Integrated System Planning (ISP)

1. **Systems vs Tools : Opportunities for new applications of ISP**
2. **Examples of work building towards ISP**
3. **Barriers and opportunities to new applications of ISP**
4. **Review of Power System Optimizer (PSO) and ENELYTIX service**

Understanding Systems vs Tools

Systems vs Tools

Historical practice leads us to combine systems and tools

- **Generation systems operations & planning = “economic”**
  - Tools: capacity expansion (CX), resource adequacy (RA), PCM
- **Transmission systems operations & planning = “reliability”**
  - Tools: system stability, protection, balancing performance
- **Terminology contributes to perceived complexity**
  - Economic operations & planning is important for all systems: generation, transmission, distribution, gas, hydro, other energy
  - Reliability analysis is needed in operations & planning of all systems

Important applications are missing from current processes

- **Opportunities to apply tools in new ways to integrated energy systems**

Opportunities for New Processes

Tools

Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

Tools can integrate a wide variety of energy systems

- Increasingly important to understand risks / benefits of coordinated operations & plans

Traditional Applications of Tools to Systems

Tools

Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

Historically, systems have used distinct processes and platforms

- Different data, tools and assumptions
- Inefficient and inaccurate coordination between processes

Integrated System Planning

Tools

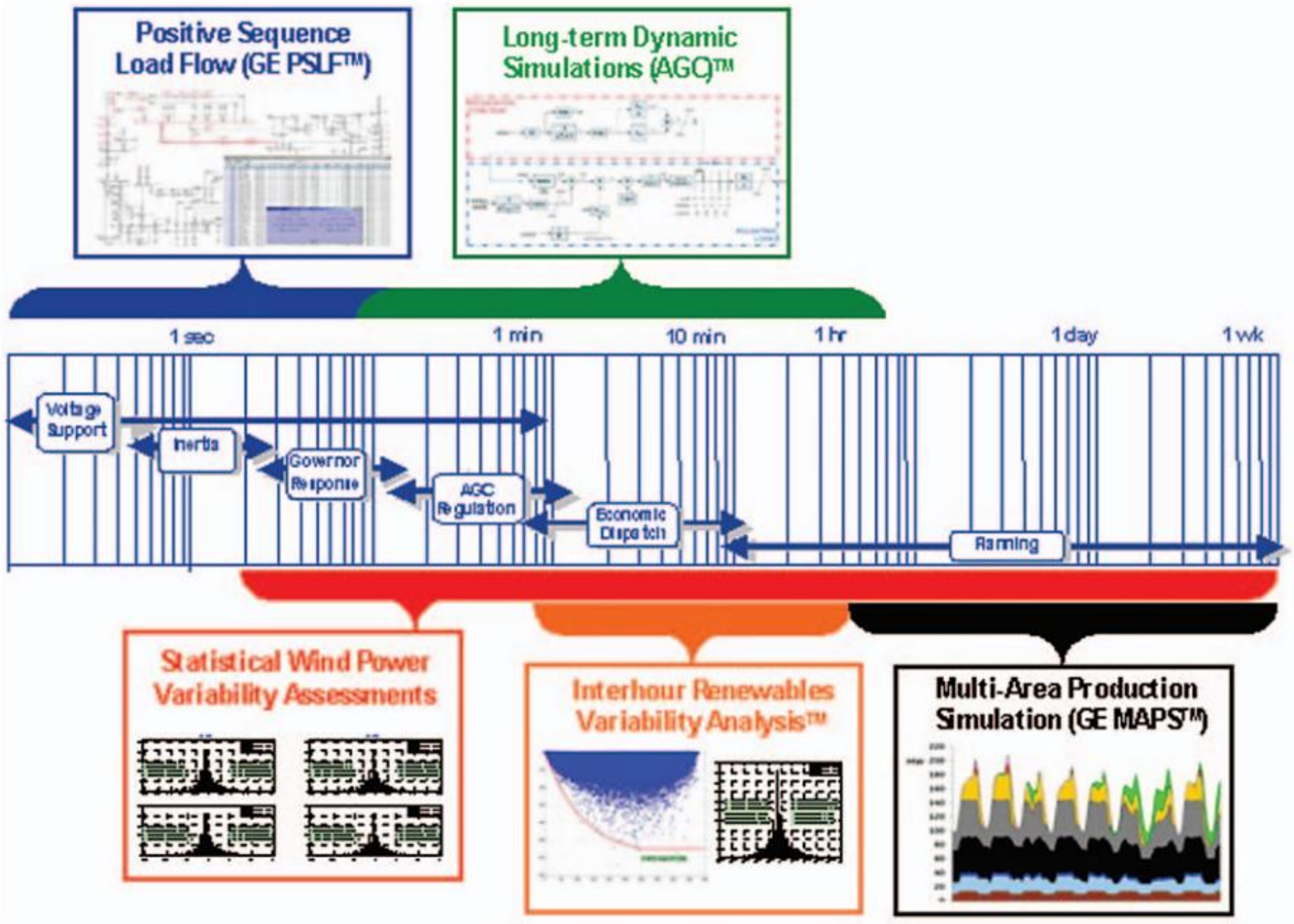
Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

However, processes can use shared data, tools, and assumptions

- Processes could combine different tools; however, this is hard without standards
- Differences in data and assumptions create significant challenges (e.g., nodal vs zonal)

Early Example: HNEI Hawaiian Island Studies (2015)



Evaluated renewable integration and storage in grid optimization

- Technology showcase of how "economic" and "reliability" tools could be used
- An early example of "co-simulation" using a mix of existing and prototype tools

Early Example: GE Hawaiian Island Studies (2015)

Tools

Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

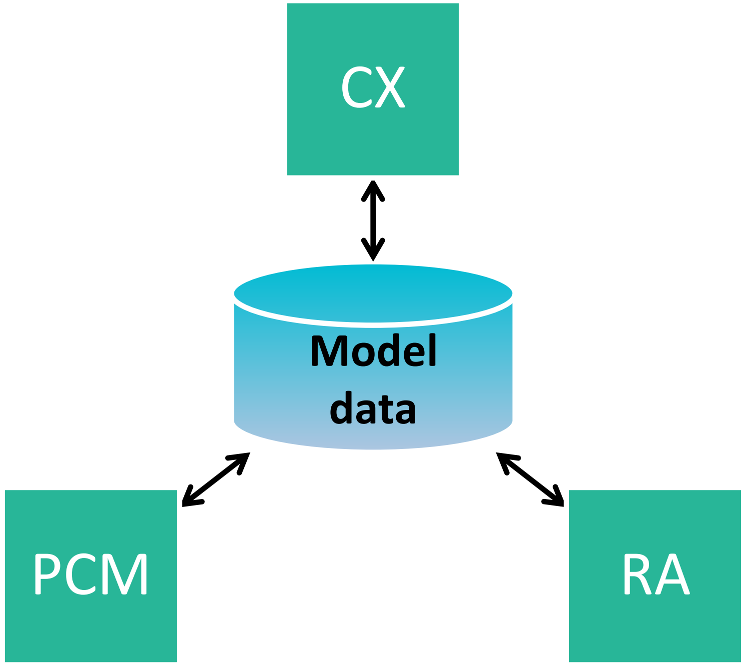
A showcase bridging “economic” and reliability” domains

- No traction other than research (e.g., LA 100 “co-simulation”)
- Need to improve efficiency and reduce costs (i.e., process engineering)

How to Improve Efficiency?

Need integration of

- Processes
- Data
- Tools



Choices

1. **Standardization of data interfaces and data assumptions**
2. **Co-ordination of interfaces and data assumptions between vendors**
3. **Single-vendor solutions**

Systems and Tools Addressed by PSO

Tools

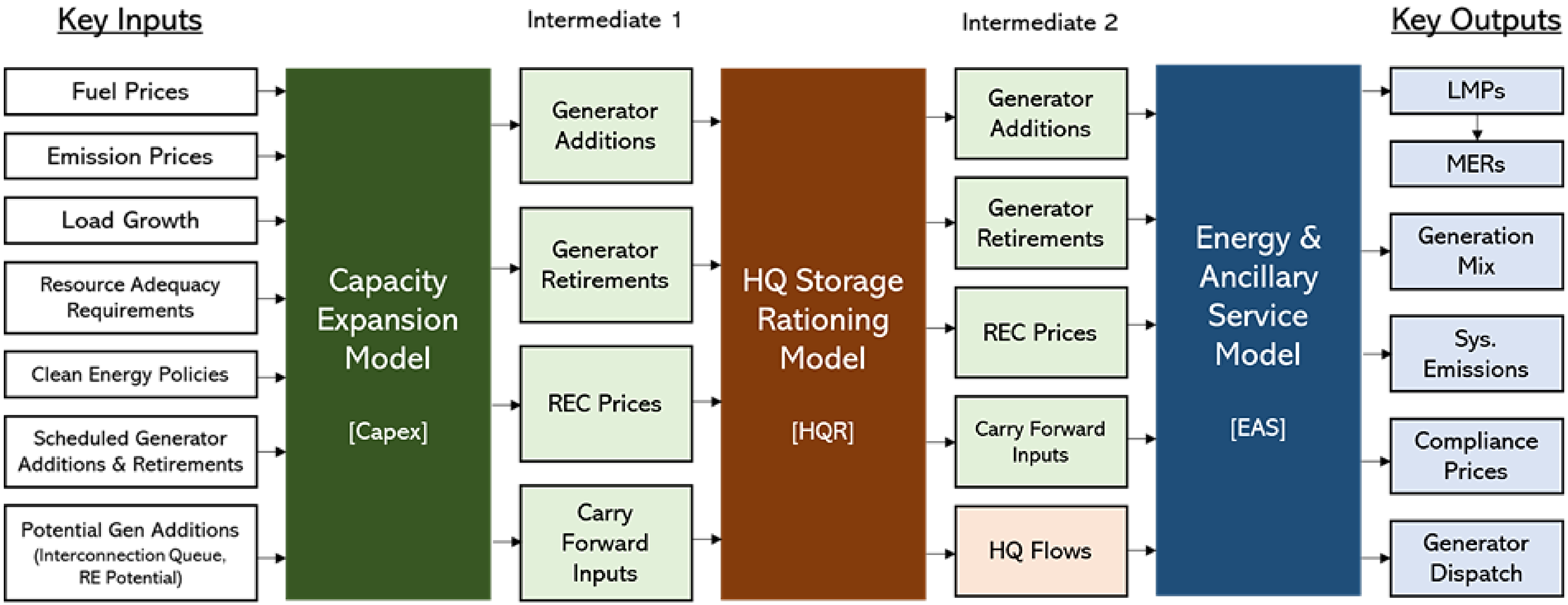
Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

Efficient modeling and low process cost

- Shared dataset, assumptions, granularity (e.g., resource models, AS, nodal vs zonal)
- PSO provides advanced and unique capabilities for CX, PCM, RA

Example: Hydro Quebec LDES Service to New England



Integrated planning of LDES in future grid to support energy and AS needs

- Nodal capacity expansion planning efficiently integrates with PCM
- Long-horizon model of LDES integrates with rolling-horizon PCM

Example: Hydro Quebec LDES Service to New England

Tools

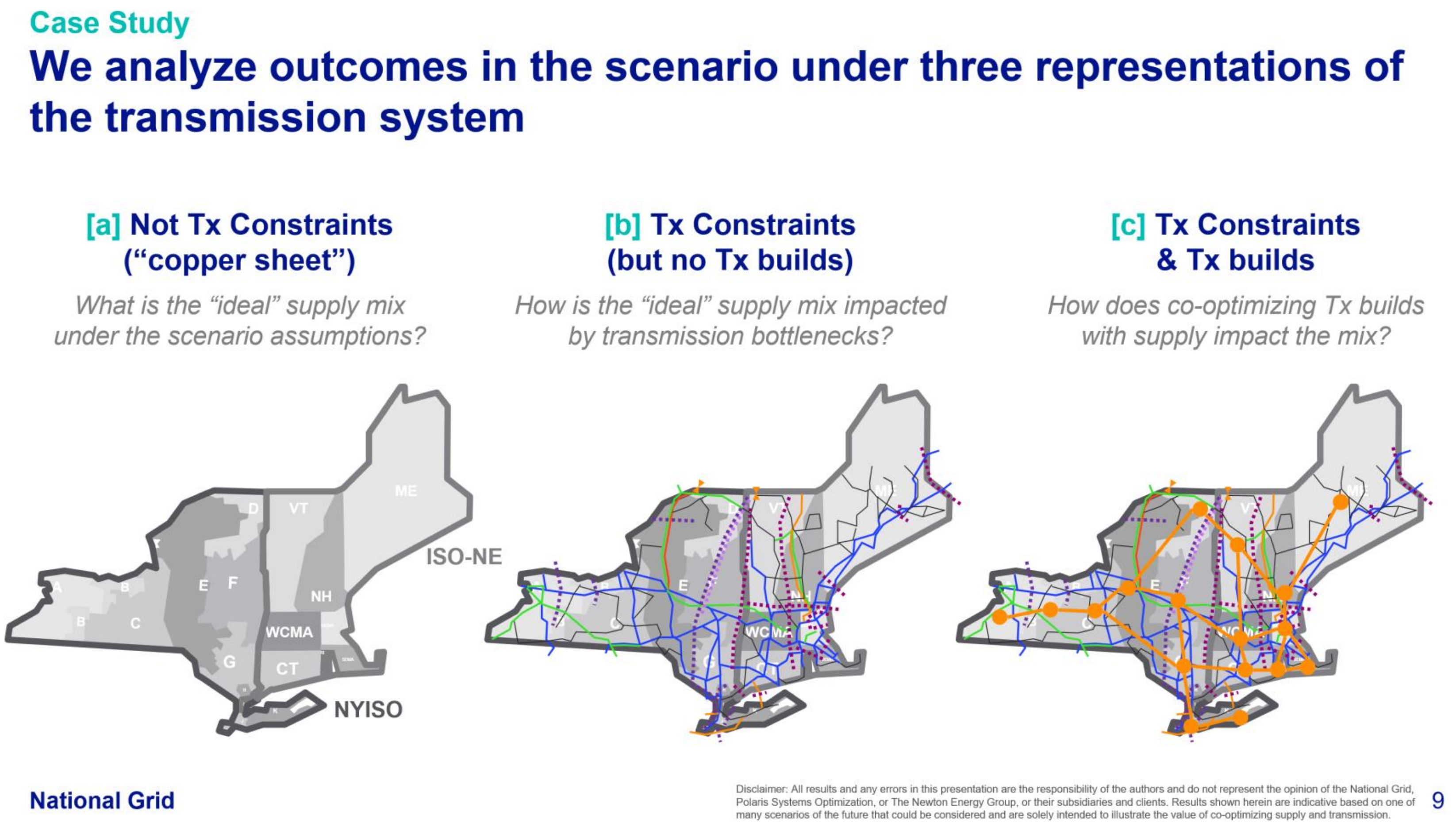
Systems	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

Efficient integrated planning of capacity expansion (CX) and PCM

- Seamless integration of nodal Tx models: No need for zonal transmission models
- Good example of integrated planning, but only a small slice of the potential

Example: Co-optimizing Planning of Generation & Transmission

National Grid, FERC Software Workshop, 2021



Forecast of Tx expansion to 2050 and generation co-optimization

- Physics-based nodal model of system in capacity expansion framework
- Captures impact of new Tx on existing transmission

Example: Co-optimizing Planning of Generation & Transmission

Tools

Systems

	CX	PCM	RA	Stability	Ops perf	Other
Generation						
Transmission						
Distribution						
Gas systems						
Water systems						
Heat systems						
Other energy						

First utility application of nodal transmission expansion

- Applied by National Grid (US) since 2021 in long-term planning
- Continues to be the only industry example of optimized transmission expansion: Why?

Solutions exist but are not widely used

Change Is Hard

Changing existing processes is nearly impossible because it requires

- Investments in new tools, system integration, and perhaps data
- Investments in people to develop and accept new processes

Existing processes are used far beyond their useful life

- Particularly for regulatory or administrative processes, however imperfectly

Opportunities for change are often limited to

- Financial opportunities in unregulated environments (trading, services)
- New processes
- Crisis response

Scorched earth

- Negative experiences with functionality deployed by vendors

Examples of New Processes

Barriers to change are lowest when no incumbent solutions exist:

- Co-optimization of power systems and gas systems
- Co-optimization of transmission and generation expansion
- Operational risk assessment (new roles for RA)
- Operational simulation (e.g., balancing performance)
- Market design simulation
- Practical wide-area modeling (multi-area, multi-interconnection)
- Integrated economic and reliability modeling (e.g., BAAL, inertia, fault current)
- P2X, X2Y and other energy conversions
- Long-duration storage optimization (fuels, emissions, policies)
- Nodal modeling and all above in PCM, RA, and capacity expansion

PSO and ENELYTIX as Solutions

- **Tools**
- Data
- Processes

The Vision Behind PSO and ENELYTIX

Industry transformation

- **Weather** dependent resource mix
- Increasing **variability** and **uncertainty** in operations
- Growing impact of **extreme weather** events
- Increasing **complexity** of system planning

Important operational details missing from planning processes

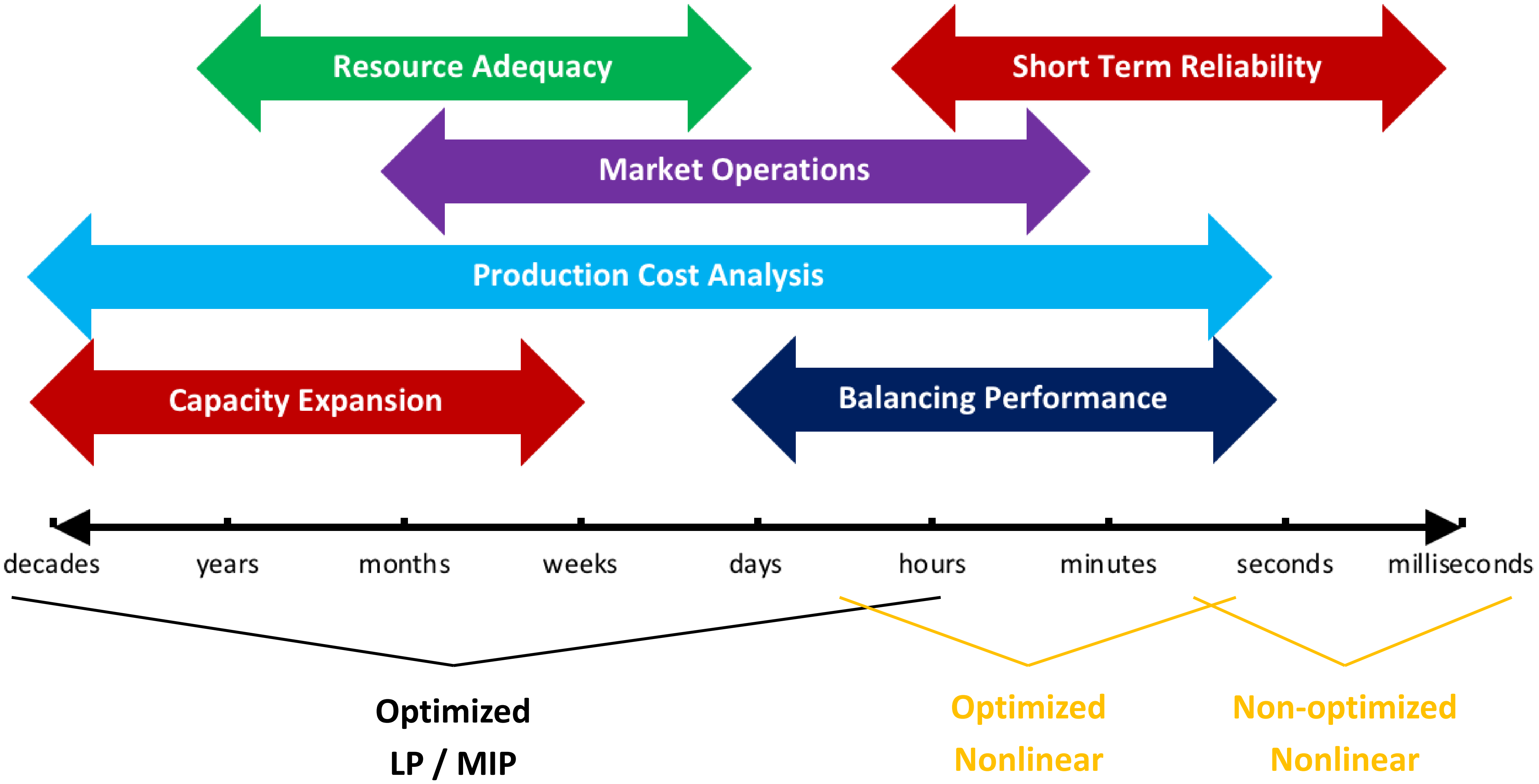
- Planning and market design tools should capture the effects of **decision processes** on system fundamentals
- Critical for **market design** studies
- Essential for capturing the **value of flexibility** in operations and planning

Increasing computational complexity

- Mixed-integer optimization
- Need for **probabilistic** modeling
- Interactions between **multiple decision cycles**
- **Interdependency of processes** and need for workflow integration

Solutions Span “Economic” Planning realms*

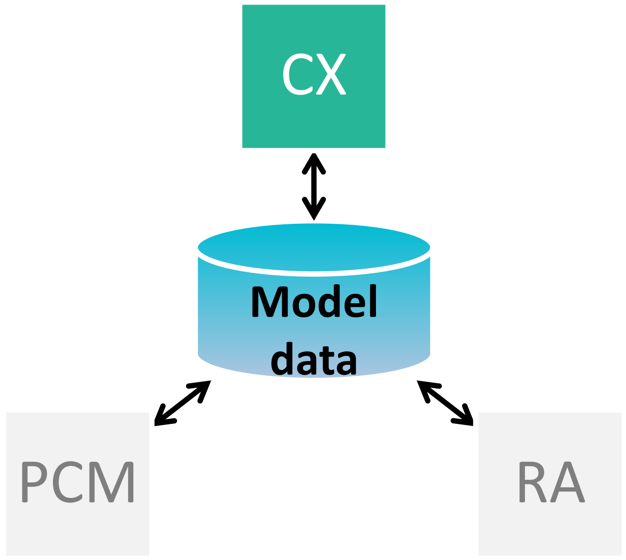
With increasing representation of “reliability” issues



PSO Advanced and Unique Features

Capability	Network Modeling	Operational Fidelity	Resource & Technology Modeling	Stochastic & Integrated Systems	Advanced Computation
Nodal and/or zonal across all tools (CX, RA, PCM)	✓				
Detailed wide-area models	✓			✓	
Fast security analysis (N-1, N-n), nomograms	✓				✓
Operational simulation of variability & uncertainty		✓			
Fastest and most accurate UC		✓			✓
Primary and secondary frequency response		✓	✓		
Flexible resource models (existing and future)			✓		
Detailed SDES and LDES			✓		✓
Other storage models (fuels, emissions, hydro)			✓		
P2X, X2Y energy conversion			✓		
Monte Carlo & stochastic models (all tools)				✓	✓
Gas-systems modeling with varying complexity			✓	✓	

Platform Capabilities: Capacity Expansion (CX)



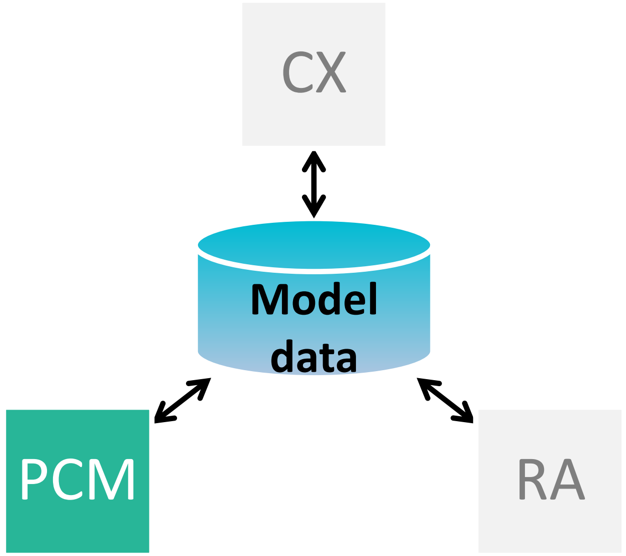
Unified database for CX and PCM

- Consistent representation across tools and systems
- Detailed representation of resources and flexibility
- No inappropriate simplifications (e.g., nodal vs zonal)

Efficient modeling of chronological constraints

- Three models of chronology: “full-explicit”, “semi-explicit”, and “implicit”
- Evaluates both long-duration and short-duration energy storage
- Evaluates “storage” constraints of fuels, emissions, policies
- Evaluates reduced flexibility from unit commitment and ramping

Platform Capabilities: Production Cost Modeling (PCM)



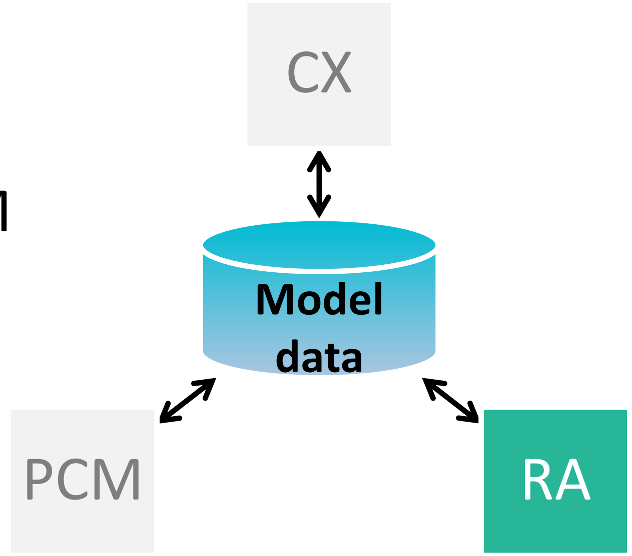
Accurate and efficient modeling of operation impacts

- Based on unique decision-cycle implementation
- Simulate all operational processes where needed
- Economic and reliability impacts of resource flexibility
- Reliability impacts of uncertainty and AS deployment
- Value of storage, improved forecasting, changing operations

Efficient wide-area modeling

- EI, WECC, ERCOT, … all in one model
- Detailed unit commitment and security-constrained nodal analysis
- Unique operating rules and transaction costs across balancing authorities

Platform Capabilities: Resource Adequacy (RA)



Detailed probabilistic analysis

- Efficient implementation incorporating full details of PCM
- Flexible definition of shortages
- Accurate simulation of resource flexibility
- Value of flexibility
  - generation, load, storage, transmission, gas systems, and other energy systems

Impacts of extreme events

- Correlated impacts driven by weather and forced-outages
- Statistically significant evaluation of low-probability, high-impact events
- Avoids need to pre-define reliability events (e.g., scenario reduction methods)

Complexity Made Manageable

What others say is hard is achievable with the right tools and approach

Perceived industry challenges

- Fragmented data standards
- Multiple incompatible data sets and models
- Computationally intense

PSO and ENELYTIX solution

- Unified and consistent datasets and assumptions
- Seamless integration across tools and systems
- Advanced, efficient computation

Myths

Nodal capacity expansion not practical
Missing solutions for optimizing LDES
Detailed probabilistic analysis is too hard

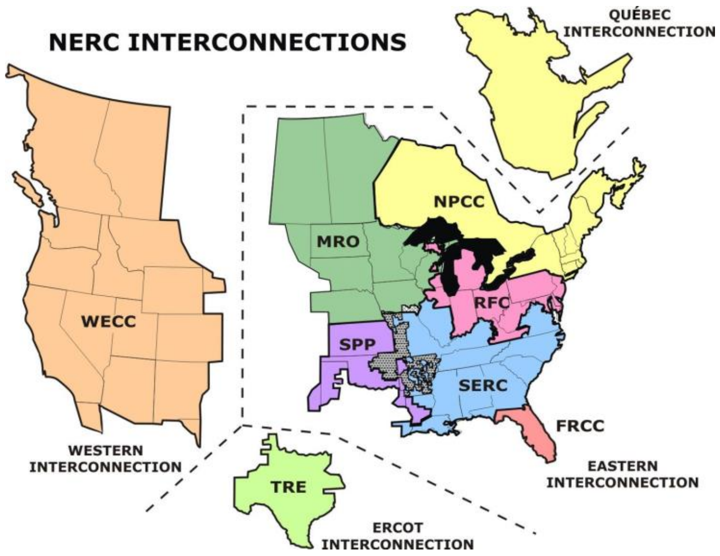
Reality

Nodal CX used for over 5 years (NG, TCR)
Solved problem: learn from others (HQ)
Regularly used by traders, consultants

PSO and ENELYTIX as Solutions

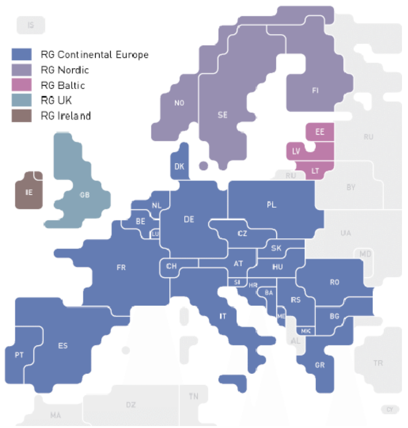
- Tools
- **Data**
- Process

Data Coverage



ENELYTIX ready-to-run data cover all three interconnections serving United States and Canada

- Data are assembled from a variety of public sources
- Verifies and to the extent necessary supplemented with internal research
- Comprehensive sets of weather scenarios



ENELYTIX ready-to-run data for Europe (ENTSO-E)

- Data are assembled from a variety of public sources
- Verifies and to the extent necessary supplemented with internal research

Data Layers Allow for Detailed Representation of the Energy System

Data Constraint Layers *

Financial / investments

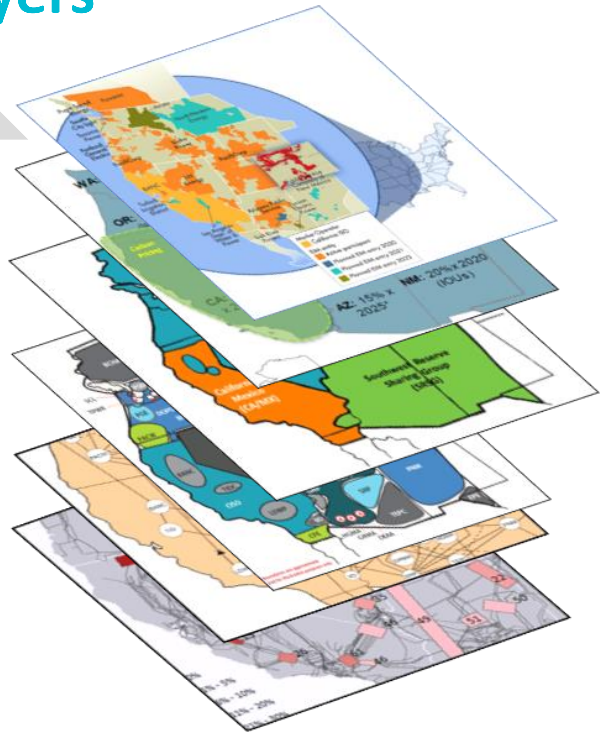
Clean Energy & Other Policies

Resource Adequacy

Ancillary Services

Contractual

Physical Flows, Energy Balance, Operational



* Credit to The Brattle Group

Optimization is subject to layers of data

- physical
- operational
- reliability
- environmental
- contractual
- financial

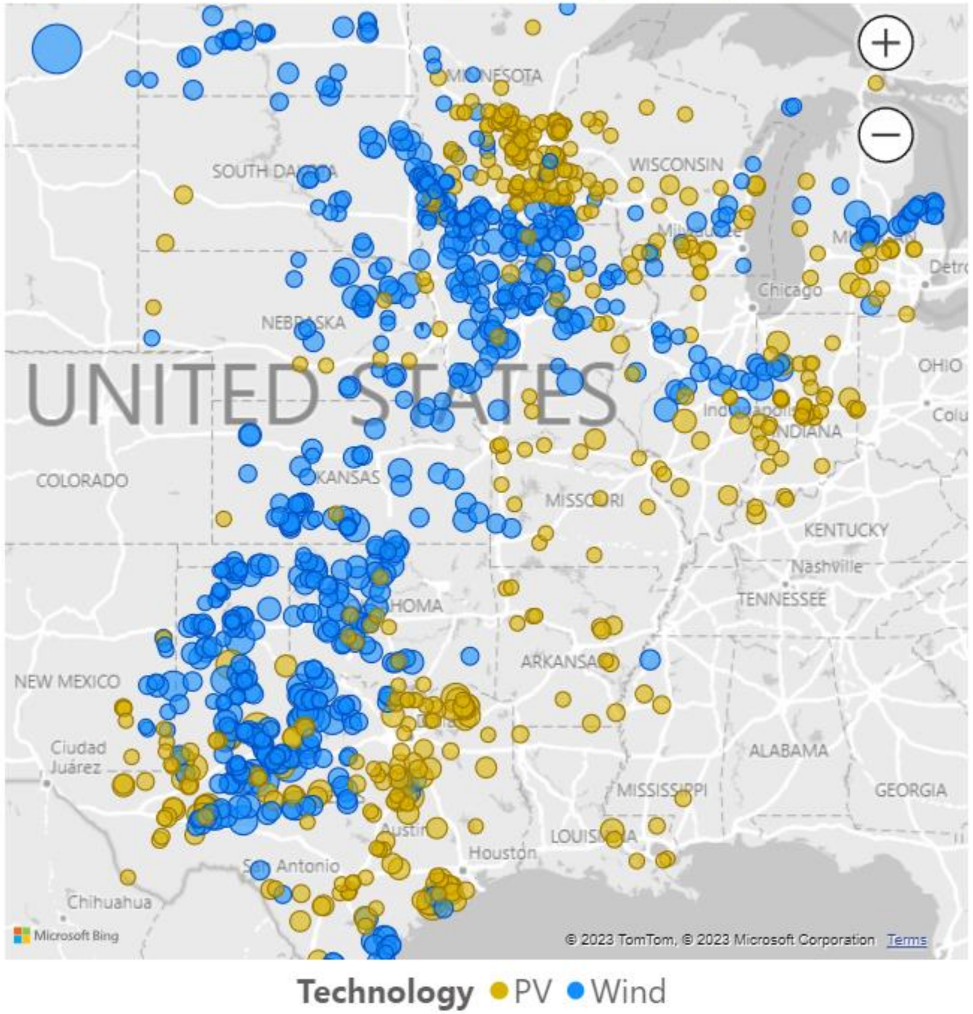
Overview of ENELYTIX Weather

ENELYTIX Weather provides weather-informed generation profiles for wind & solar power plants

Existing Plants
- location-specific weather data
- sensitive to plant technology
- calibrated against historical generation

Prospective Plants
- API to evaluate new builds

Wind and Solar Fleet: ERCOT, MISO, SPP



PSO and ENELYTIX as Solutions

- Tools
- Data
- **Processes**

Accessing PSO Capabilities

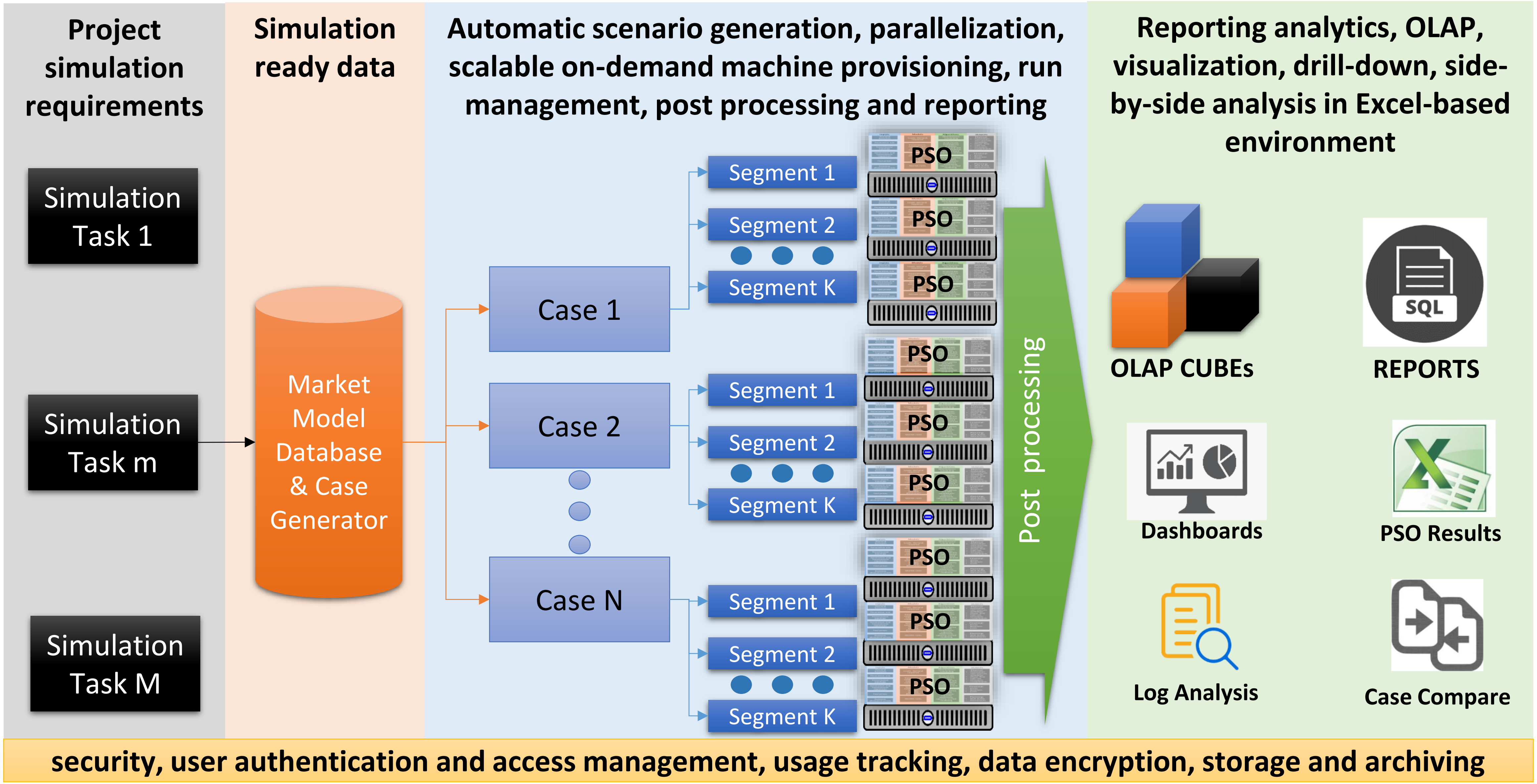
Deployment options

- Command-line execution (e.g., in-house without need for internet connection)
- Cloud service though ENELYTIX platform for scalable, parallel processing

Licensing options

- Per-seat, unlimited use
- Usage based (pay-as-you-go or annual/multi-year subscription)
- Free non-commercial use (e.g., PSOscholar)
- Free limited-use commercial applications (PSOexpress)

ENELYTIX Parallel Architecture



Questions?

Contact info:
Russ.Philbrick@psopt.com