Integrated Planning Virtual Workshop

SYSTEM EXPANSION MODELING

Workshop Organizers
Energy Systems Integration Group
and Breakthrough Energy

November 18, 2024

ESIG

This virtual workshop (recording and presentations at https://www.esig.energy/integrated-planning-forum/) on November 18, 2024, included 230 participants from 21 countries and regions including Africa, South America, Australia/New Zealand, East and South Asia, Europe, and the Caribbean. This workshop followed up on the Integrated System Planning Workshop in Providence, Rhode Island, on October 21, 2024, which focused on integrated planning for different entities, specifically regional transmission organizations versus vertically integrated utilities.

Presenters included:

- Dr. Debra Lew of ESIG
- Dr. Bryan Palmintier of NREL
- Dr. Chris Clack of Pattern Energy (formerly Vibrant Clean Energy)
- Luke Falla of the Australian Energy Market Operator
- Dr. Schuyler Matteson of the New York Department of Public Service
- Obadiah Bartholomy of Sacramento Municipal Utility District
- Aaron Burdick of E3

Introduction

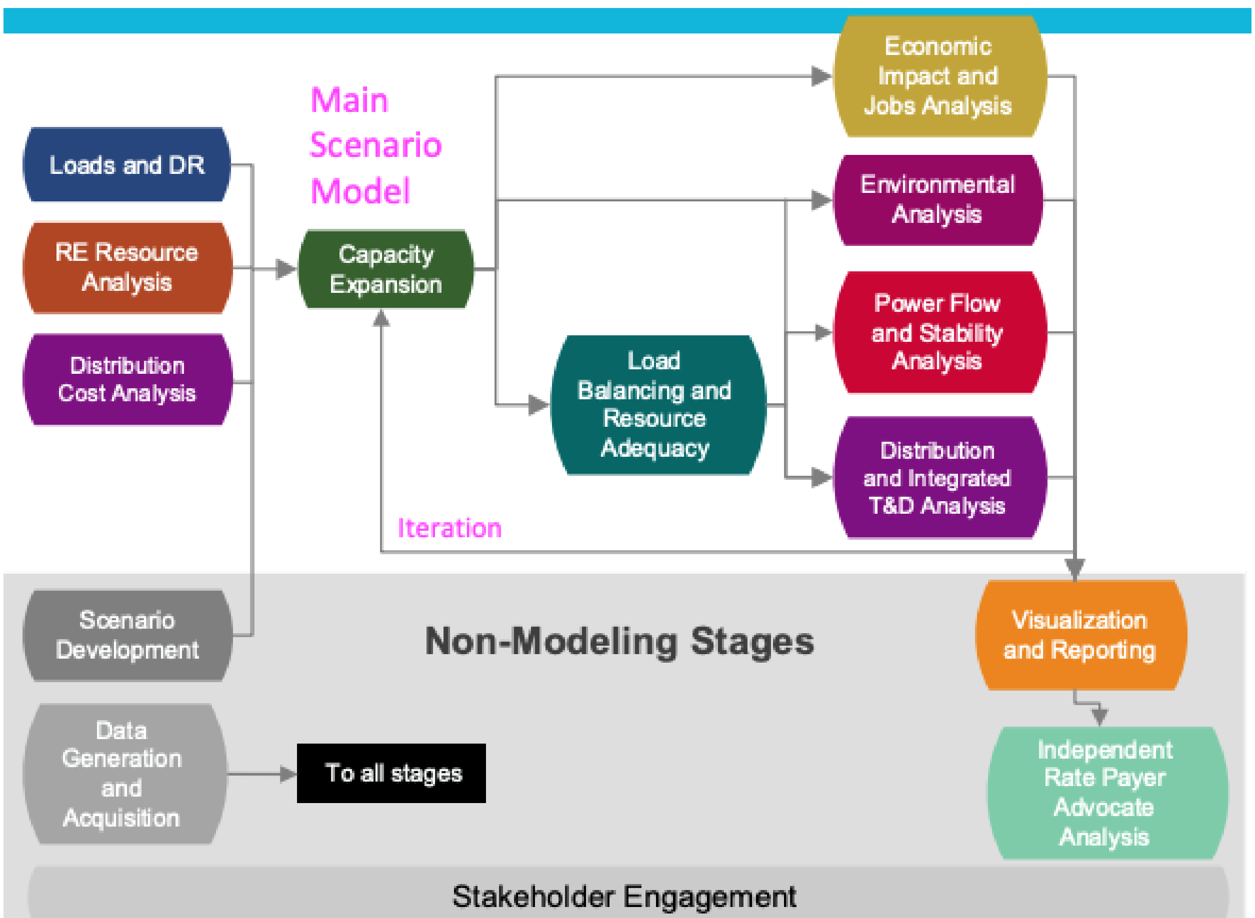
Debra Lew introduced the workshop and described how the focus of this integrated planning activity at ESIG is on better integration of generation, transmission, distribution, and customer loads/distributed energy resources. This work does not focus on gas-electric coordination or hydrogen or other molecules.

This virtual workshop was a deep dive into system expansion modeling with a focus on how traditional capacity expansion modeling needs to evolve beyond its economic optimization of generation resources to include transmission and distribution system expansion and also customer loads and distributed energy resources.

Debra explained that increasingly, generation, transmission, distribution, and customer loads/distributed energy resources can be somewhat fungible. For example, storage could replace the need for distribution upgrades, transmission between regions could replace the need for additional generation capacity, or time-of-use rates could replace the need for storage. However, there is no tool that can optimize across all of these domains simultaneously. How planners manage this complex world was the theme of this workshop.

LA100 Study – Los Angeles Department of Water and Power

Bryan Palmintier discussed how aggregated models can be used to analyze complex systems at the distribution level, but challenges arise when details from different scales don't fit into the same paradigm. An alternative approach is to use multiple tools that iterate with each other to find a solution, such as using expansion planning models to inform adoption models for the distribution side. NREL's LA100 study explored pathways to 100% renewables, involving granular modeling of loads, electric vehicles, buildings, and distribution systems, as well as resource adequacy and production cost analysis. The project used a variety of tools, including load modeling, dGen for distributed resource adoption, capacity expansion modeling, with some iteration between tools (i.e., resource adequacy, production cost, and power flow results make adjustments to the capacity expansion modeling). What was unique about this study was the spatial and temporal granularity with which it modeled loads (residential and commercial buildings, transportation, individual industrial facilities, and water loads) and distributed energy resource adoption (detailed distributed solar photovoltaic adoption included iterative hosting capacity analysis). The study found significant increases in electrification, renewable resources, and storage, but also identified challenges in getting to 100% renewables, including the need for clean dispatchable technology. The modeling steps are shown below.



Source: Bryan Palmintier, NREL, 11/18/24

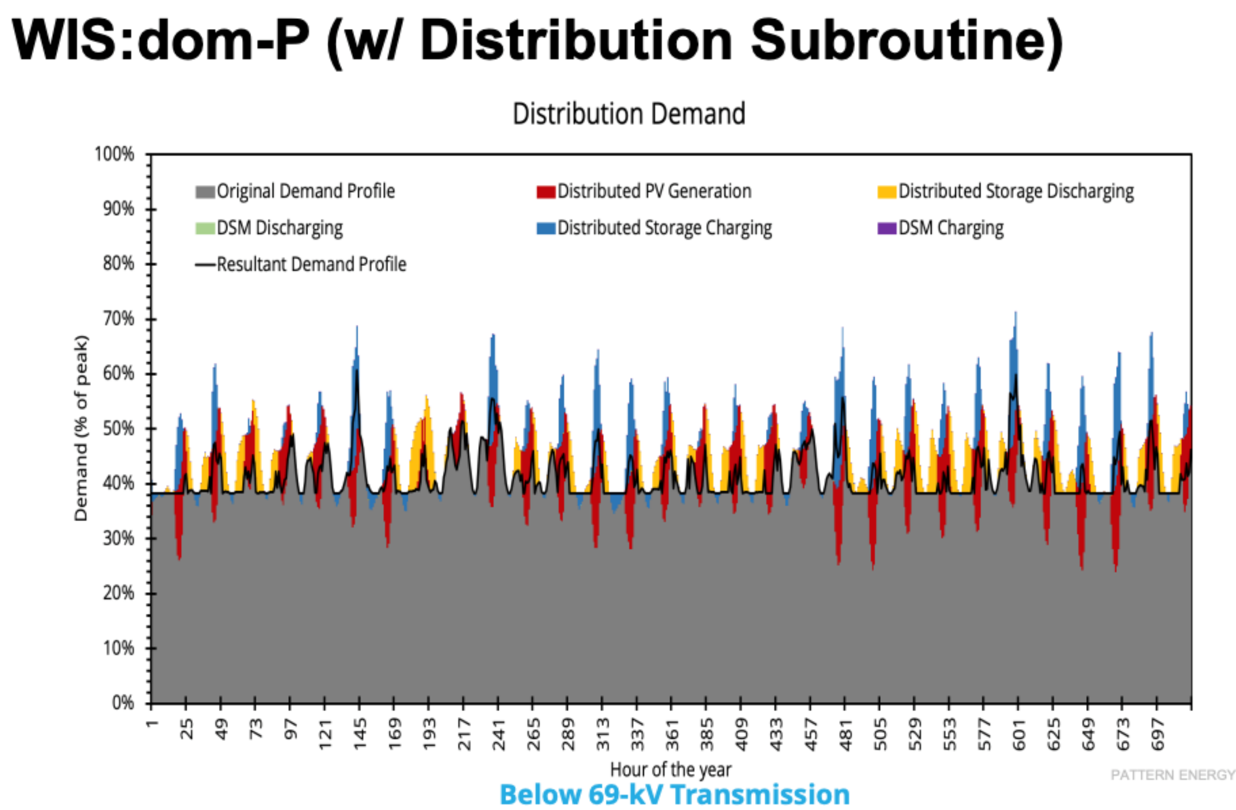
Bryan also briefly mentioned the National Transmission Planning Study which itself is an excellent example of bulk power system integrated planning across economic and reliability domains. There have been increased efforts around integrated distribution planning, recognizing the need to capture distribution value streams and distributed energy resources within larger-scale system planning studies. The Global Power System Transformation Consortium (GPST) is working on interoperable data among different pieces, to have specifications, tool interfaces, and the ability for tools to work closely together.

WISDOM Model and Its Applications

Chris Clack introduced the WISDOM model, an acronym for Weather-Informed Energy Systems for design, operations and markets, combines production cost and capacity expansion to understand how weather shapes the economy, particularly the supply and demand sides of the energy sector. This model is unique in its ability to model not just the bulk power system but also down to the distribution interface, where it optimizes distribution upgrade costs along with transmission expansion and generation/storage capacity expansion.

The model traditionally runs at a county level with hourly resolution for weather drivers, but can go down to more granular resolution, which has a trade-off with solve times. The core data sets used include traditional utility-scale generators, transmission systems, buildable areas, demands, and climate change, which is a whole tier of modeling that drives differences in weather. Load modeling at the distribution level involves housing age and size and space and water conditioning resources and profiles. Critically, the model uses high-resolution multi-year weather data rather than a single year. The weather data inform not only wind output and load but also things like transmission ratings and losses.

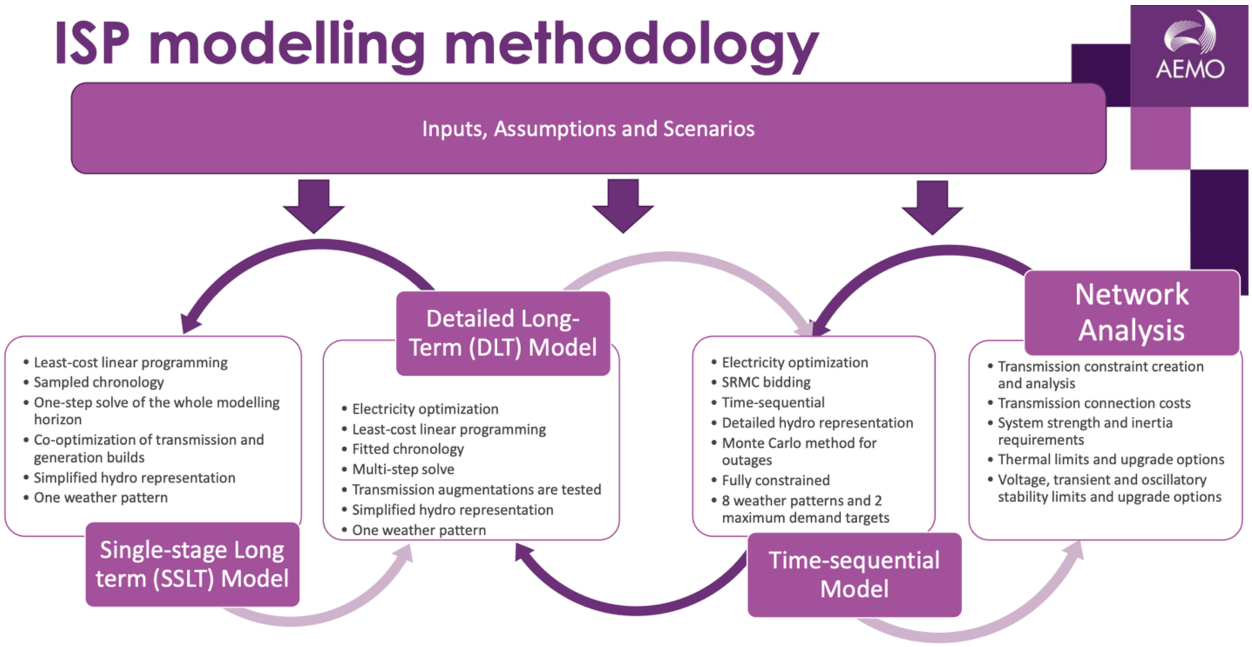
When the model is run without the optimization across the distribution interface, the distribution demand is peaky with a low load factor, due to baseline demand and the effects of distributed solar. When the model is run with the optimization across the distribution interface, the distribution demand flattens out as storage and demand response help increase the utilization of distribution infrastructure as shown below. Capturing the distribution upgrade costs is crucial, as it can offset other costs elsewhere, and not accounting for these costs can lead to inaccurate results.



Source: Chris Clack, Pattern Energy, 11/18/24

Australian Energy Market Operator and Integrated System Plan

Luke Falla presented the Australian Energy Market Operator (AEMO) Integrated System Plan which aims to integrate transmission, generation, and distribution factors to achieve a net-zero emissions target by 2050, with a focus on phasing out coal and increasing renewables. The plan uses a capacity expansion model to determine the optimal development path, including the retirement of existing generation and the integration of new renewables and storage. A traditional generation expansion model is used, which starts with a single-stage long-term model and is then iterated upon with a detailed long-term model that includes more detail and fidelity as shown below. The model also includes a time-sequential model that checks the reliability and constraints of the network, and a full load flow representation of the network is used to check the results. The model includes gas market representation, generation retirement and expansion, transmission network expansion, and renewable energy zones.



Source: Luke Falla, AEMO, 11/18/24

The Integrated System Plan is a two-year process with extensive engagement with stakeholders. The plan aims to improve the inclusion of distribution costs in the model, and they are currently consulting on the best approach to achieve this, with the goal of having a more integrated generation, transmission, and distribution outcome by 2026.

New York State's Coordinated Grid Planning Process

Schuyler Matteson discussed New York's coordinated grid planning process to achieve 100% zero-carbon electricity by 2040, as mandated by the Climate Leadership and Community Protection Act of 2019. The process involves a three-year cycle, with six stages, including data collection and capacity expansion modeling, power flow and short circuit models, local area studies, and solutions development, solution evaluation, least cost assessment with transmission refinements added to the capacity expansion modeling, and a final least-cost plan report. The goal is to identify "no-regrets" solutions that are necessary in all scenarios.

They use PLEXOS as the capacity expansion modeling, and this is run by NYISO and includes 230 kV and above transmission. Optimization includes: generation resources by zone, operation of storage, flexible resources and electrolysis and headroom requirements. The model's limitations include not being able to optimize the distribution mix, not having full chronology, and not being able to endogenously model long-duration storage. They iterate with distributed energy resource mixes including quantity and location and transmission upgrades. The desired future model would be able to co-optimize with distribution resources, have full chronology, and be able to look at long-duration storage.

Sacramento Municipal Utility District's Capacity expansion planning with Distributed Energy Resources

Obadiah Bartholomy presented the Sacramento Municipal Utility District (SMUD) 2030 Zero Carbon Plan, which includes four primary pillars: repurposing natural gas generation; investing in solar, wind, and storage; focusing on new technology and business models; and maximizing community benefits. SMUD's integrated resource planning process involves capacity expansion modeling (using RESOLVE, SERVM, and PLEXOS) to identify the least-cost portfolio, loss-of-load probability modeling to ensure resource adequacy (using RECAP and SERVM), and production cost modeling to examine economic dispatch (using PLEXOS). Their Zero Carbon Plan was created using RESOLVE. Optimization results were refined through iterative processes.

SMUD's analysis (by E3) on virtual power plants (VPPs) found that 1.7 GW of VPP resources were selected to meet their 2030 needs, displacing geothermal, wind, and storage. The VPP provides both energy and capacity and saved $1.9 billion by avoiding expensive resources. Obadiah showed E3’s modeling approach to include VPPs that includes an avoided cost analysis, a VPP incremental cost analysis, dispatch of the VPP to maximize flexibility without disturbing the customer, and including in the capacity expansion modeling.

The integrated distribution resource plan update is focused on understanding transportation electrification growth, grid impacts, and the role of demand response and distributed energy resources in mitigating those impacts. The integrated distribution resource plan found that to serve 50% more energy by 2040, about 40% of substations would need to be upgraded at a cost of over $1 billion, but managed charging could cut that in half.

Time-of-day rates for residential customers have been successful in displacing capacity and getting behavioral response, with 97% of customers staying on the rate and actively saving about 130 MW of demand during hot days (4% of total peak load and 10% of residential peak).

Integrated Planning Task Force and White Papers

Aaron Burdick, chair of ESIG’s Integrated Planning Task Force, closed the workshop by describing the three white papers being developed, including one on economic optimization for integrated planning, which will discuss the benefits and challenges of co-optimization similar to the discussions today. The task force is exploring how to integrate transmission, distribution, and customers into the existing optimal generation expansion problem and assessing what alternatives to full system co-optimization may be effective.