Integrated Planning Workshop

Workshop Organizers
Energy Systems Integration Group,
Global Power System Transformation Consortium,
and Breakthrough Energy

Occtober 21, 2024

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

This in-person workshop (recording at https://www.youtube.com/watch?v=QT9nB7eYFdU and presentations at https://www.esig.energy/event/2024-fall-technical-workshop/) was held in Providence, RI, on October 21, 2024 and included 218 participants from 16 countries including Europe, East and South Asia, Australia and South America.

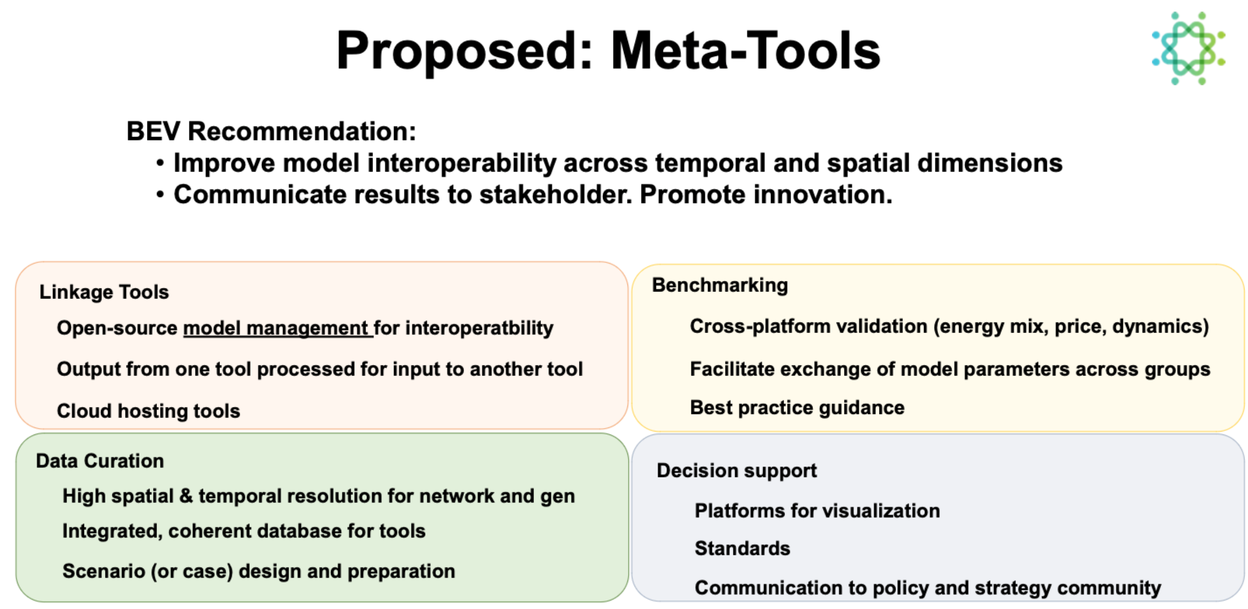
Presentations included:

- Dr. Rajeev Ram, Breakthrough Energy

- Integration of Economic and Reliability Tools and Data, moderated by Carlo Brancucci, encoord
  - Jordan Bakke, Midcontinent Independent System Operator
  - Peter Markussen, Denmark's Energinet
  - Jason Frasier, New York Independent System Operator
  - Dr. Xiaoyao Zhou, UK's National Energy System Operator
  - Kelsey Allen, Southwest Power Pool

- Integration of generation transmission, distribution and customer load/distributed energy resources, moderated by Arne Olson of E3
  - Dr. Paul Denholm, NREL
  - Ken Aramaki, Hawaiian Electric Company
  - Angie Bond-Simpson, Salt River Project
  - Dr. Chris Clack, Pattern Energy
  - PJ Martin, Xcel Energy

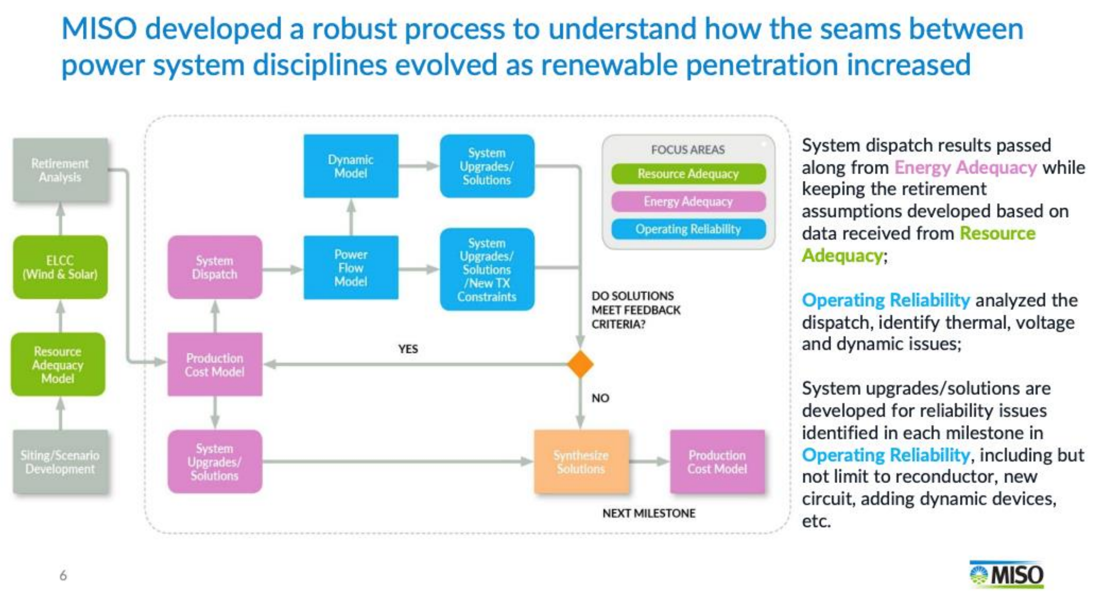
Rajeev Ram explained Breakthrough Energy's work including investments in commercial ventures, policy work, and sciences work on tools and data. Breakthrough's Grid Modeling Initiative is looking at how to integrated across the suite of power system planning tools and how to improve model interoperability and better communicate results. It has four areas: linkage tools, data curation, benchmarking, and decision support. A goal of this activity is to enable other entities to undertake more integrated studies with higher granularity such as LA100 (Los Angeles' Department of Water and Power's study of 100% clean energy).



Source: Rajeev Ram, Breakthrough Energy, 10/21/24

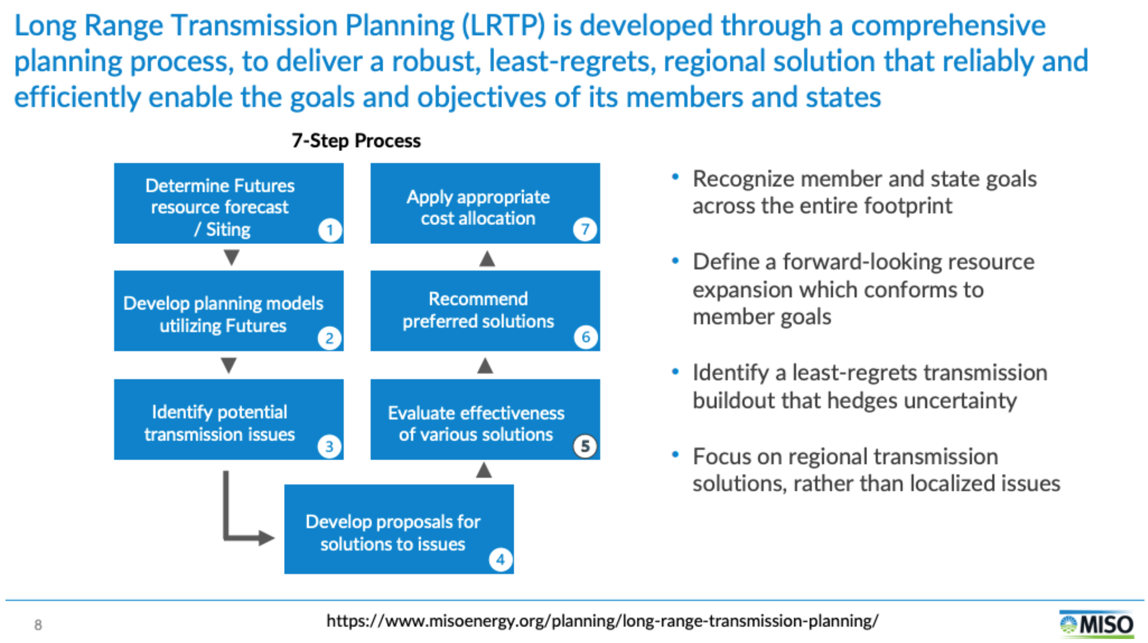
Integration of Economic and Reliability Tools and Data

The first session focused on integration of tools and data. Jordan Bakke presented the Midcontinent Independent System Operator (MISO) Renewable Integration Impact Assessment, which is the one of the most comprehensive examples of integrated planning to date, with extensive economic and reliability studies conducted over steps of increasing renewables penetration. Of particular interest may be the detail to which MISO went in the dynamic stability studies, examining frequency response, transient voltage stability, rotor angle stability, and small signal stability.



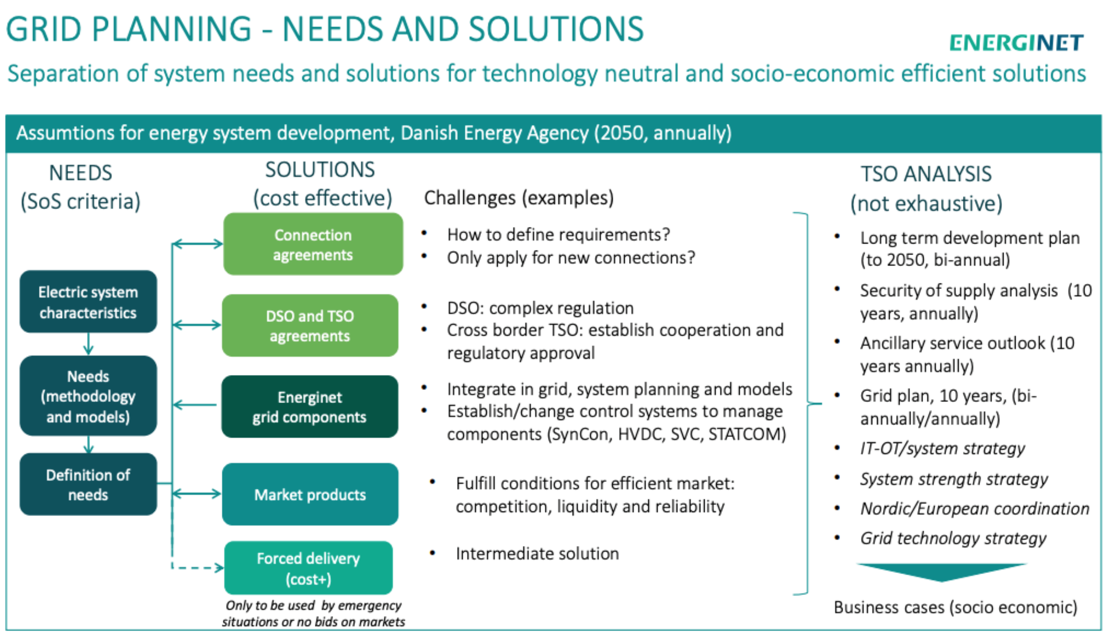
Source: Jordan Bakke, MISO, 10/21/24

MISO has since applied increasingly integrated planning processes in its Long Range Transmission Plans. Multiple scenarios are examined using MISO Futures, which are created in a separate stakeholder process. This enables siting of resources, and then production cost modeling, power flow modeling, and dynamic stability can be conducted.



Source: Jordan Bakke, MISO, 10/21/24

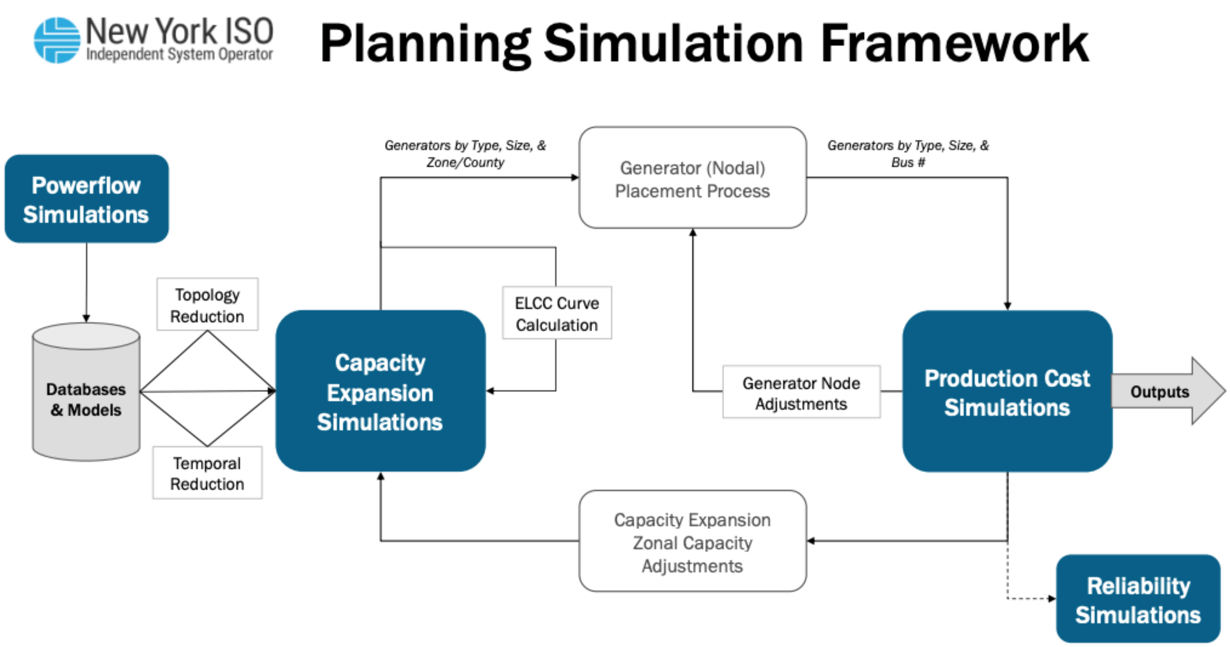
Energinet is Denmark's transmission system operator, and it oversees both gas and electricity system operations and markets. Peter Markussen discussed how a long-term development plan is created to set the overall framework, which includes security of supply analysis, looking at generation adequacy, grid adequacy, system robustness, and IT security. The system strategy is analyzed to determine the necessary systems, models, and compliance for the future, including system strength, inertia, and stability. A grid technology strategy is being developed to determine the necessary grid technologies and their inclusion in long-term planning. Separate business cases are created based on the analysis, which need to be approved and are based on socioeconomic analysis, including security of supply, environmental values, and tariff influences. The business cases are evaluated based on four criteria: socioeconomic analysis, security of supply, environmental values, and tariff influences.



Source: Peter Markussen, Energinet, 10/21/24

Jason Frasier, senior manager of transmission planning at the New York Independent System Operator (NYISO), explained that NYISO plans for the transmission system and power markets. The three main legs of the NYISO process are reliability, economic, and public policy, with multiple interconnected processes and arrows pointing back and forth to each other. He noted that the people involved in the process really matter, and having engineers who can integrate models and processes effectively is essential for success. Integrating models and processes requires a deep understanding of various aspects, including power flow models, production costs, and reliability planning. Jason showed how the NYISO planning simulation framework involves multiple processes, including capacity expansion, production costs, and power flow simulations, all of which feed into each other (see below).

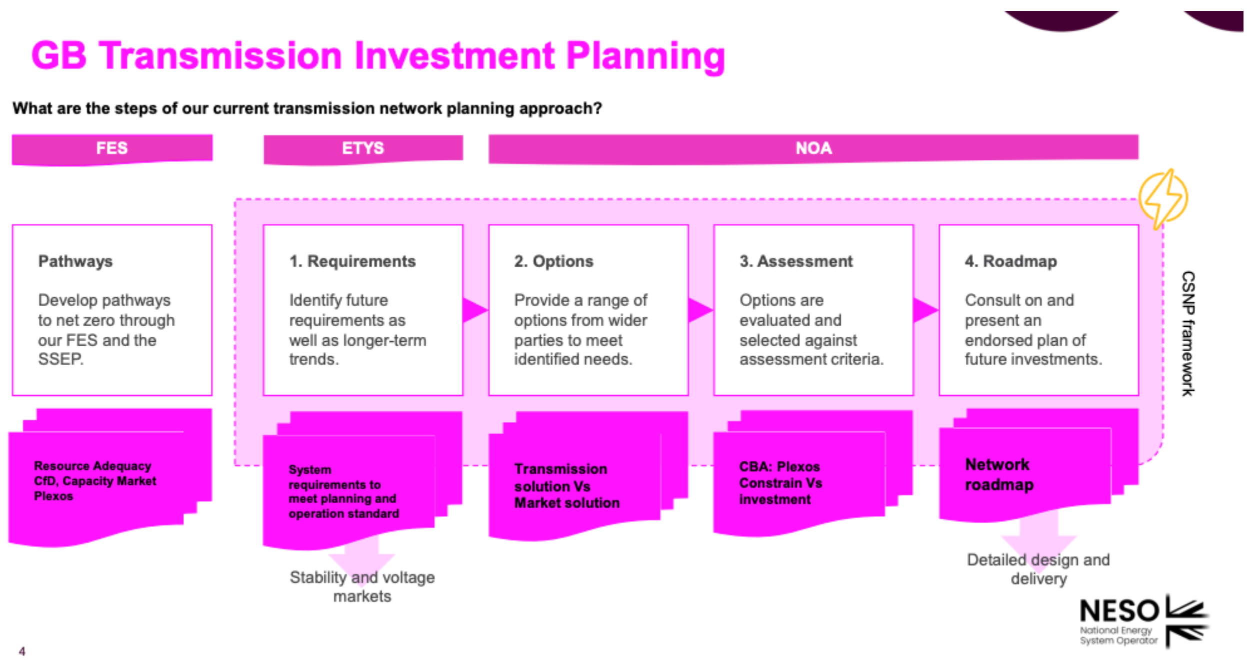
Good data and models are essential for starting the process, and the output involves predicting the future system through various sensitivities and scenarios. The process of analyzing the system and identifying potential needs and opportunities involves a wide range of factors, including reliability needs and opportunities for investment, with the goal of determining the best time for transmission investment. A reliability need is an area where an actual need for investment is triggered, which must go through a process at NYISO, while opportunities are identified through a more creative and R&D-focused approach. It's clear that the independent system operators are doing more R&D-focused work. The full framework involves many different feedback loops, which is a nod to how integrated the models need to be to capture the challenges facing the industry.



Source: Jason Frasier, NYISO, 10/21/24

Next discussed was the UK's National Energy System Operator (NESO), formerly National Grid ESO, which oversees the whole energy system, including electricity, gas, hydrogen, and other energy-related planning. Xiaoyao Zhou discussed how they have been transitioning toward net zero with a significant increase in renewable generation and the retirement of existing coal-fired power stations. They have over 20 GW of offshore wind and an instantaneous penetration level of up to 75%. One of the major issues facing the NESO is designing the transmission system for the massive renewable generation connections and determining the best time for transmission investment (see steps below). They have worked with industry and stakeholders to create future energy scenarios which depict credible scenarios that can help achieve the zero-carbon target set by the government.

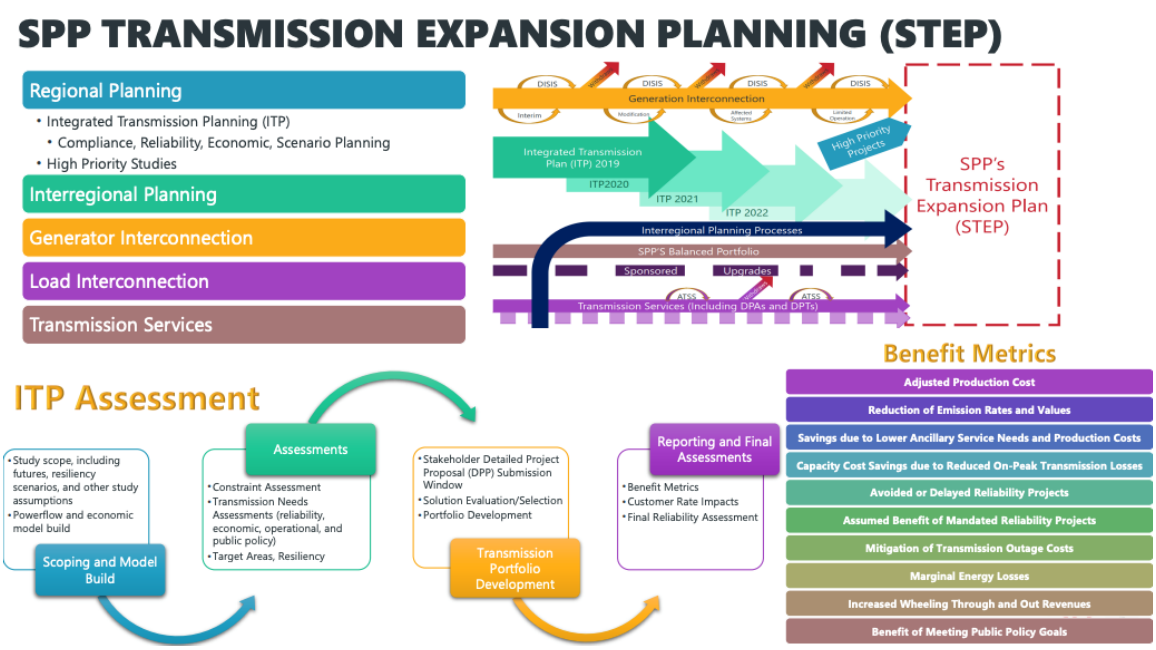
Once the scenarios are fixed, the next step is to identify what the system needs, including transmission capacities, additional capacity requirements, system stability, and voltage-related issues. They use this information to look at possible transmission reinforcement options, including increasing transmission capacity or adding reactive capability and compensation equipment. The cost-benefit analysis involves running future scenarios through PLEXOS to determine the overall system cost with and without additional transmission reinforcement. The outcome of the analysis is a list of optimal transmission investment solutions, considering not only cost but also deliverability, environmental impact, and other aspects. The overall cost benefit of the consumer is considered after a list of recommended transmission reinforcements has been compiled, which is then published annually and sent to the regulator to determine the right investment plan for transmission companies.



Source: Xiaoyao Zhou, NESO, 10/21/24

Kelsey Allen of the Southwest Power Pool (SPP) discussed SPP's role as a regional transmission organization operating an energy market and planning transmission across 14 U.S. states. The process at SPP is similar to other independent system operators, with a focus on planning processes under the transmission expansion plan, including integrated transmission planning, inter-regional planning, generator interconnection, load interconnection, and transmission services. SPP's integrated transmission planning process considers compliance issues, reliability issues, economic issues, public policy, scenario planning, and system resilience. The planning processes at SPP are disjointed, running in parallel, and optimizing across different planning processes can be challenging.

SPP's integrated transmission planning assessment involves scoping and model development, looking at different futures to support economic analysis, resilience scenarios, and other study assumptions. The process involves working closely with reliability and economic teams, building models, and conducting transmission assessments to identify system needs, including reliability criteria violations, economic congestion, operational needs, and public policy. The transmission planning process involves a robust evaluation of reinforcements needed for the system, considering various portfolios and metrics such as benefit metrics and impacts on customer rates. The current planning process assesses the value of transmission on the back end, leveraging adjusted production cost savings to drive transmission selection, but there is a need to move some of these metrics up to provide more value in project selection and portfolio development.



Source: Kelsey Allen, SPP, 10/21/24

Challenges and Approaches to Quantifying Tradeoffs in Transmission Investments

The U.S. independent system operators have moved in a common direction, incorporating reliability, economic, and public policy drivers into the transmission planning process, with some differences in structuring these processes. Traditionally, the transmission planning process was driven by reliability, but there is a need to consider other factors such as economic and public policy drivers. The main challenges in quantifying tradeoffs between economic and reliability impact when evaluating transmission investments include siloing within system operators and between processes and tools, and the need to balance economic and reliability analysis. Jason noted that while there are good tools and engineers working on quantifying technical challenges and metrics, the main challenge lies in the siloing of needs into individual requirements, making it difficult to find projects that can solve multiple needs at once.

Xiaoyao said that their main challenge is balancing economic and reliability impact, as reliability analysis is often a snapshot while economic analysis has a higher resolution, making it difficult to translate results from reliability analysis into economic analysis. The challenge is to find the right balance between the level of detail in reliability analysis and the need for it to fit into economic analysis, as it is not feasible to do hourly transmission reliability analysis. Integrating economic analysis and the process to look at economic and reliability investments together is crucial, and efforts have been made to design processes to answer this question over the last 15 years. Other important challenges are:

- Making data work across different tools and domains, as data come from various sources, companies, and systems, and are collected in different formats, making it difficult to compare datasets and overcome this challenge even after merging processes and conceptually understanding tradeoffs
- The development of technology and the associated costs, particularly the high increase in transmission costs and the fast reduction in storage costs, which raise questions about how to include storage in modeling.
- The dependence on neighboring countries' decisions and systems, as changes in their systems require remodeling
- The increasing uncertainty in the system due to the penetration of renewables, electrification, and resilience scenarios, which affects quantification and feeds into other challenges
- The diverse input from stakeholders across different regions, such as the 14 states and Canada and Texas

Data Management and Model Integration in Planning

The planning process is complex, and investing in models and data is crucial, with a focus on ensuring data compatibility between economic and reliability studies. Industry is trying to beef up databases and automation to correlate different datasets and make them compatible. Building models and taking snapshots from production cost models to build reliability models is a challenging task, and cross-validation of results and co-optimization are also difficult. A significant amount of time is spent on data and analysis, with one colleague finding that they spent 70% of their time on data and 30% on analysis, highlighting the importance of efficient data management. It's essential to have a single point of responsibility for data management to avoid confusion and inefficiency.

Common platforming and technology are crucial for moving data around efficiently, and investing in a common data repository, often in the cloud, can help streamline data management and reduce silos. Data collection is another critical area, and creating new tools and standards for collecting data from members and external sources can help eliminate data silos and improve data quality. Standardized data formats and departments in charge of standardizing and collecting data are essential for effective planning and coordination.

Organizational Structure and Collaboration in Integrated Planning

Operationally, it's essential to create a linkage between planning and operational stages to ensure that assumptions made during planning are taken into consideration in the real system. Engineers who have rotated through different departments and worked with various tools are valuable assets, as they can leverage their experience to improve processes and models.

Engineers often focus on technical solutions, while economists look at the business case, and politicians consider the overall policy objective, highlighting the importance of understanding different perspectives. Collaboration with other system operators and organizations, including planning software vendors, is crucial for advancing integrated planning processes, and finding common goals is essential for successful collaboration.

Collaboration with Vendors and Other System Operators

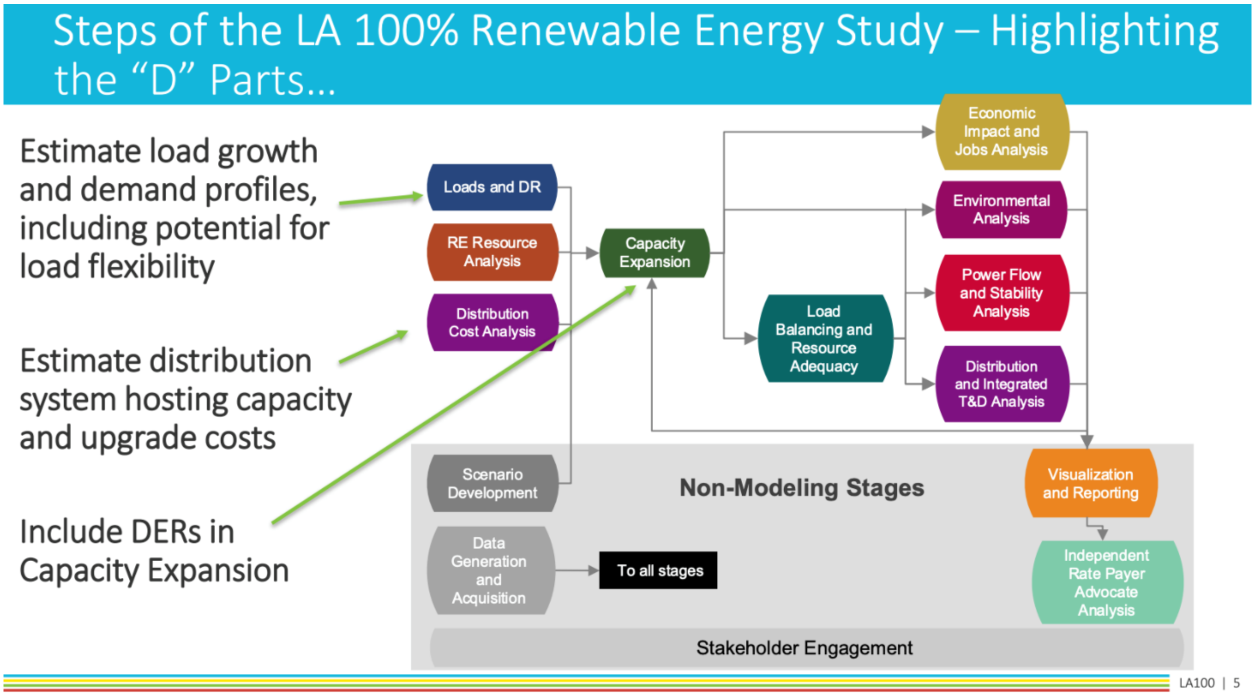
Vendors are becoming more innovative, but continued feedback and collaboration with them is necessary to meet the needs of companies, and working with vendors is an ongoing process. Collaboration with other system operators in the industry is beneficial, as it allows for the identification of common issues and easier conversations with vendors.

Integration of Generation Transmission, Distribution, and Customer Load/Distributed Energy Resources

Arne Olson of E3 opened the second session, which discussed integrated system planning across transmission, distribution, generation, and the customer. Customers are increasingly taking charge of their own energy destinies and adopting technologies that allow them to respond more flexibly, such as automated control technologies, rooftop solar, and energy storage systems like batteries, which will drive the need for integrated planning. System planning needs to be more customer-centric.

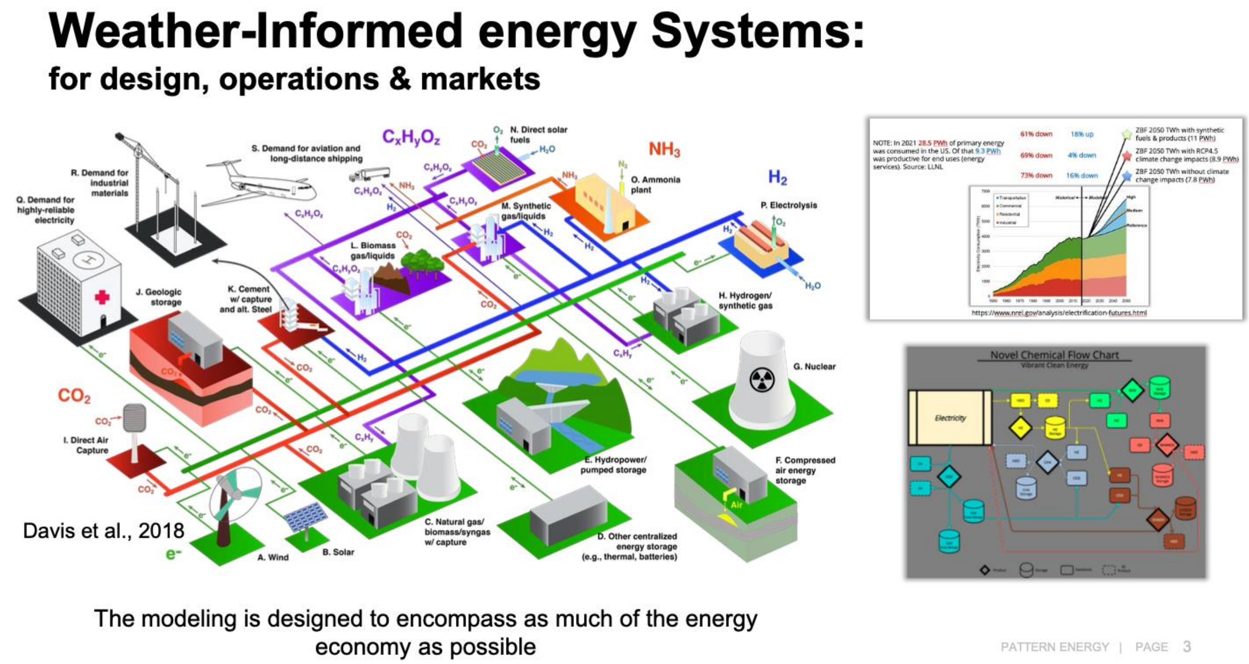
Paul Denholm of NREL presented LA100, which explored the costs, environmental implications, local job impacts, and environmental justice aspects of achieving 100% renewable energy in the Los Angeles Department of Water and Power region. NREL worked to improve planning and integration of the transmission and distribution systems and to address technical issues, but also to explore non-technical questions that are not well understood. Challenges in distribution planning include looking at loads from a bottom-up standpoint, using a physics-based approach to understand load profiles and potential flexibility. This approach involves simulating buildings with retrofits to understand how flexible the load might be and also considers non-physics-based factors like electric vehicles and industrial flexibility. The discussion also touched on the idea of combining bottom-up and top-down approaches to load forecasting.

Capacity expansion models, such as the classical capacity expansion part, are used, but the biggest challenge is incorporating distributed energy resources into these models, as they do not account for consumer interactions with the power system. dGen was used to forecast and site these resources. Understanding adoption of distributed energy resources is difficult because the value of solar is expected to change, and tariff structures and potentially net energy metering regulations may change as the value of solar changes. All of this will impact distributed solar and storage adoption. The importance of achieving a truly cost-optimum mix of resources is emphasized, with a need for more work to be done to get the math right and address non-math, policy-oriented aspects of integrated planning. The LA100 study was noted to be a time-consuming and extensive effort, with the question raised of whether utilities need to spend more money and time on bottom-up planning or whether there's a middle ground.



Source: Paul Denholm, NREL, 10/21/24

Chris Clack, founder of Vibrant Clean Energy which was sold to Pattern Energy, discussed WISDOM, the integrated planning tool that he created. The economy is interconnected, and the electricity sector is considered the backbone, with various energy transmission and distribution systems branching out from it. All datasets, including buildable areas, are related to the weather in some way, affecting build times and other factors. Weather shapes both the supply and demand of electricity, with big spikes in demand occurring during winter, and these spikes are difficult to manage due to limited flexibility in time periods with very cold, not very windy, not very sunny conditions. Transmission ratings and heat rates are also weather-driven, and including these factors in modeling is crucial to accurately assess the grid's performance. Water availability and heat rates are also affected by climate change, further complicating the problem. Long-term averages of wind and solar output can be misleading, and models should solve for resource adequacy over multiple years to accurately assess the grid's performance. Then Chris presented the RARE (Resource Adequacy Renewable Energy) dataset which he is releasing for the public's use in time-series modeling of wind and solar on a country-level basis.



Source: Chris Clack, Pattern Energy, 10/21/24

Ken Aramaki of Hawaiian Electric Company (HECO) discussed HECO's integrated grid planning process, which started in 2018 and resulted in the approval of their first integrated grid plan in 2024. HECO's integrated grid planning process started due to discussions with stakeholders and communities, aiming to inform, educate, and provide input opportunities. Prior to 2018, the level of integration of across siloes was low and has improved greatly, although some siloes still exist. The organization has more interplay between areas, with constant discussions and feedback loops to ensure that plans are developed and designed together. The changing nature of the supply-side portfolio affects the value of customer-level initiatives, and utilities need to adapt by sending signals to designers of customer programs. The power system is changing, and some of the signals being incentivized today, such as electric vehicle charging overnight, are the opposite of where they need to be in the future. HECO is trying to understand where the value lies, including time-of-use rates with a super off-peak and conservation window.

Angie Bond-Simpson discussed Salt River Project, a public power utility in the desert Southwest that started integrated system planning conversations in 2019 and launched a public-facing plan in 2021. Prior to 2019, Salt River Project had a siloed approach with individual departments having deep knowledge and specialization but also having different objectives that sometimes conflicted. Individual relationships played a significant role in integrating across departments. The catalyst for integrated system planning at this utility was the publication of an integrated resource plan and corporate sustainability goals in 2017, which caused internal conflict and highlighted the need for a more integrated approach. She highlighted how the main issue with siloed approaches is that each department has different objectives, which can lead to conflicts and difficulties in achieving overall organizational goals. The objective of a utility company is to strike a balance between affordability, sustainability, and reliability to provide the best overall customer value, rather than achieving the perfect optimal plan in each area. Achieving integrated planning depends on personal relationship and proactive and forward-thinking leadership.

While the value of resource adequacy or capacity value for distributed energy resources is low for Salt River Project, there may be value in resilience or customer-driven initiatives. Technical constraints need to be removed to allow for interconnection, and programs are being developed to build load during daytime hours and align conservation programs. Electrification programs are being explored to build load during the daytime, and conservation programs such as cooling load, air conditioners, and weatherization are also important.

PJ Martin of Xcel Energy discussed the company's integrated system planning journey, which began a couple of years ago. Xcel’s 2016 request for proposals required interactions between different groups, such as generation planning and transmission, and indicated to the company that more integrated planning was necessary. The company had to consider transmission upgrade costs, generation interconnection agreements, and other factors, leading to conversations between different groups and the need for co-optimization of generation and transmission investments. The integrated system planning team absorbed modeling teams from electric distribution and gas and required changes in mindsets and culture. Instead of their traditional focus on five-year budget planning, they had to refocus on integrated planning and coordination. This was driven by senior leadership, including Senior Vice President Alice Jackson. Two key needs of this group were to ensure transmission availability for new renewables and to proactively plan the distribution system.

Challenges and Opportunities in Managing Distributed Energy Resources

Care must be taken because customers can be confused when asked to change their behavior after decades of being told to do something else. Customer-sited battery storage, such as home batteries, and other technologies like water heaters, offer opportunities for load flexibility. Designing programs that can flex load without impacting system peak is essential, and this flexibility has been a long-sought goal in the industry. At Salt River Project, a time-of-use pilot program was implemented to incentivize customers to shift their load during the day when solar generation is high, and this has led to customers exploring larger storage solutions to displace their evening peak. However, there are challenges with implementing such programs, as they may not always work as intended, particularly on days with low solar generation.

Upgrading the customer information system to push changes to individual meters is necessary, but this process is likely three to four years away.

Modeling and Optimizing Distributed Energy Resources in Capacity Expansion

Participants were asked about whether distributed energy resources should be a solution in a capacity expansion model rather than an input. Differing opinions considered the multiple decision-makers with different motivations, profit factors, regulators, and jurisdiction and distorted price signals in retail rates, which can affect customer behavior and investment decisions. It can also increase the computational complexity of the model and its solve time. The current approach to modeling involves using exogenous input and separate studies for demand response and energy efficiency, which may not be a perfect approach due to the homogenization of different resources into buckets, resulting in a loss of granularity and locational benefits. There is a debate about the role of demand-side resources in capacity expansion, with some arguing that it may be misleading to consider them as a replacement for firm capacity options, while others see a potential place for them in deep decarbonization efforts. There is a need to develop faster and more compact models that can be run on desktops or large computers to solve complex energy planning problems. A continental-scale model is desirable, but it's challenging to do justice to the diversity of potential resources that can be deployed at the customer level.

Integrating Customer-Sited Resources into Requests for Proposals and Planning Processes

Salt River Project uses customer-sited solar as an option in their requests for proposals, allowing grid services and aggregators to compete with larger renewable resources. Xcel typically considers solar projects with a threshold of around 5 MW, although smaller resources are also present on their systems, and some request for proposals processes include small solar requirements for various states.

A key barrier is the structure of the regulatory process because multiple groups are focused on different plans, such as integrated resource plans, distribution system plans, and gas investment plans at different times of the year. They may all be using different load forecasts as well. It was suggested that the initial filing of an integrated resource plan could be skipped and instead utilities could proceed directly to requests for proposals, especially given the current period of load growth.

Load Growth, Distribution Planning, and Non-Wires Alternatives

Xcel has incorporated integrated planning through non-wires alternatives studies, recognizing the potential of non-transmission resources to meet energy needs. Non-wires alternatives can substitute for wires investments, potentially at a lower cost to society, by combining customer generation, energy efficiency, and other demand-side resources to provide the same services as wires, but finding the right combination can be challenging. The demand-side portfolios also require management, process, and transaction costs, and there are timing and performance issues.

There was a discussion about distribution investments, which were fairly low in the LA100 study and much larger in Chris Clack's studies. Chris explained that when he does include the distribution interface in his optimization, there is less of a need for massive peaking resources and firming, and this allows for greater utility-scale wind and solar. It requires more transmission because some demand pockets become supply pockets and transmission is needed to transfer this power. The main outcome of integrated planning is an increase in utility-scale renewables, a decrease in firming technologies on the utility side, and a decrease in cost over time, although this is dependent on assumptions about economics and deployment rates.