The Transmission Planning Process

Ric Austria, Principal

Pterra Consulting

Outline

- Industry Status
- Transmission Planning Concepts
- Best Practices
- General Framework for Transmission Planning Process

Industry Status Updates

- FERC Notice of Proposed Rulemaking to reform policies regarding Regional Transmission Planning and Cost Allocation
- New York
  - State mandated a comprehensive system planning process
- New Jersey
  - State Agreement Approach (SAA) Agreement with PJM
- California
  - State direction on what models to use and scenarios to study for planning purposes

Federal: FERC NOPR

- FERC Notice of Proposed Rulemaking (NOPR) to reform its policies regarding Regional Transmission Planning and Cost Allocation issues April 21, 2022
- Would require transmission planning processes to engage in long-term planning (20 years) and evaluate transmission needs-driven changing resources and demands (consider federal, state and local laws that affect resource mix, reflect state renewable energy targets, address aging infrastructure).
- Would require that regional transmission planning processes consider dynamic line ratings and advanced power flows devices (consider new technologies)
- Consider interregional transmission projects to meet long-term needs
- "Right-sizing" replacement in kind transmission projects
- Would require transmission providers to include a process for achieving state agreement
- Would retain right of first refusal for incumbents.
- Enhanced transparency and coordination requirements within, and between, regional and local transmission planning

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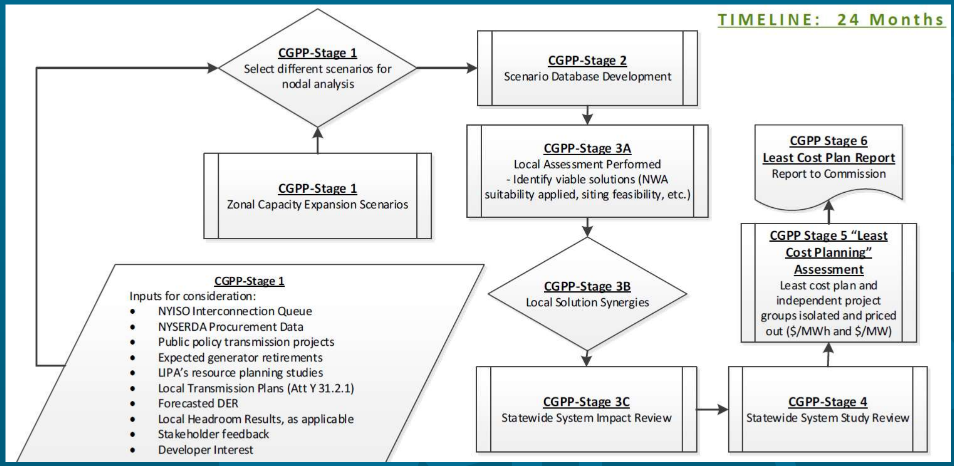
New York

NYISO

- Focuses on bulk transmission planning (per FERC Orders 890 and 1000)
- Planning process includes Public Policy Transmission Planning (PPTP) Policy
  - To date two PPTP projects have been awarded
  - One more PPTP (in Long Island) is in process (related to offshore wind integration)
- Utilities are responsible for local transmission planning

NYS Public Service Commission

- Established the Coordinated Grid Planning Process (CGPP) (Jan. 20, 2022)



- Integrated distribution planning, local organizations, and industry developers in the process
- Formalized the utility transmission planning process

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New Jersey

PJM

- New Jersey is part of PJM, the multistate grid and market operator
- Transmission planning in the PJM RTEP process is not specific to the state but included NJ in a subregion designated as MAAC.

NJBPU

- Exercised the first State Agreement Approach (SAA) was proposed and approved by FERC (April 14, 2022)
- Allows NJ to request that PJM develop transmission that would help meet the state's public policy goals.
- Intended to address the state solicitation for 7500 MW of offshore wind generation. This initiative faces the challenge of accounting the multiregional reliability requirements for generation that is only intended for the state.

California

California ISO

- Similar to NYISO, the planning process accounts for reliability, economic and public policy needs
- Overseas bulk transmission planning with input from utilities on local transmission plans
- Has accepted 6 policy-driven transmission projects

CEC/CPUC

- CISO and CEC/CPUC continue to undergo a process of alignment
- CPUC defined the base cases and sensitivity portfolios to use in the CISO planning cycle (Feb 11, 2021) that is in line with CEC's 2031 emissions reduction target.
- Also directed CISO to study potential interconnection of 8 GW of offshore wind

Transmission Planning Concepts

Objectives

- Define a roadmap for the evolution of the transmission system to:
  - Address existing operating constraints
  - Meet future locational electric demand
  - Support changing resource mix
  - Incorporate new and advancing technologies
- Focused on maximizing benefits at the "least cost"

Characteristics

- Long-term viewpoint
  - Transmission lines have 40 plus years effective lifetimes
- Robustness
  - Provide for a future transmission grid that has the least regret
- Flexibility
  - The planning roadmap provides for the ability to proceed along alternate tracts as future uncertainties change

Interconnection processes, even though these may identify transmission upgrades, are not transmission planning processes per se as these generally do not have the key characteristics listed above.

Transmission Planning Concepts

Stakeholders

- Traditional
  - Customers
  - Transmission Owners
  - Generating Facility Owners
  - System Operators
  - Regulators
- Contemporary
  - State policy
  - Developers of utility and distribution-level resources
  - New types of customers
  - Local governmental

Desired Outcomes

- Traditional
  - Reliable grid
  - Economic or least-cost plan
  - Minimize environmental impact
- Contemporary
  - Meets state public policy objectives
  - Provides headroom in locations which have high renewable development potential
  - Offers higher reliability for specific types of customers
  - Offers incentives to develop areas with favorable local policy and costs
  - Supports backfeed of DER into local transmission

Transmission Planning Concepts

Types of Planning Models

- Power flow or load flow – steady-state representation of a specific operating condition of the grid
- Market or production model – used to simulation grid operations over a period of time, typically a year, taken one hour at a time. Alternatively, an 8760-model.
- Other models include:
  - Transient or stability model – representing electric characteristics and control functions that respond to destabilizing events in the grid
  - Adequacy model – represents facilities' probability for outages
  - Electromagnetic model – represent fast transient response, especially for inverter-based resources. Used to simulate dynamic response of the grid with high penetrations of inverters and other fast controllers
  - Short circuit model – represents electric equipment instantaneous or momentary response to faults

Classification of Planning Models

- Base Cases – the starting models for a planning study representing conditions that have high certainty or are highly desired for the grid
- Scenarios and Sensitivities – alternate conditions or futures that may deviate from the base cases but are also likely or highly desired

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Transmission Planning Concepts

Umbrella Principle

- When planning for a reliable grid, the practice is to evaluate the most extreme conditions, regardless of how unlikely, that the grid may be exposed to. If the grid is able to reliable withstand these extreme conditions, the umbrella principle dictates that the grid can reliably weather any other operating condition.

Applications of Umbrella Principles

- Transmission planning models represent extreme conditions such as the peak load (highest load demand during the year) as the test basis for reliability.
- Assume that the likelihood of any single line being out of service is 100%.

Transmission Planning Concepts

Capacity and Energy Headroom

- Capacity headroom is the MW of new generation that the transmission grid can support at specific system configurations conditions. This provides a measure for how effective a transmission plan is in providing upramps for new renewable generation.
- Energy headroom is the MW-hr version of headroom. The energy headroom determines how much of a variable resource's available energy can be delivered to the grid without curtailment. This identified what types of technology may be supported by the transmission grid at specific locations.

Upramps and Downramps

- Upramps are transmission facilities that allow distributed resources to utilize the transfer capacity of bulk transmission lines. These can take the form of transformation capacity going from lower voltage facilities to higher voltage facilities, but can also include transmission lines that connect resource areas to bulk power substations.
- Downramps are facilities that allow power from the bulk power system to reach lower voltage systems where most of the electrical load is located. Typically downramps are located as close as possible to where the customer loads are to avoid the loss penalty from using lower voltage lines. Transmission planning requires advance information on where downramps and load centers will be located.

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Transmission Planning Concepts

Jurisdictions

- FERC-jurisdictional transmission facility
  - Bulk power, inter-state, interregional, “backbone” transmission
  - Typically 230 kV and above
  - Lower kV transmission that has resources participating in regional energy markets
- State and local facilities
  - Subtransmission and distribution facilities (except as noted above)

Planning Entities

- Regional or state system operators
- State planning agency
- Individual utilities

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Selected Best Practices

- **Horizon Year Planning** as contrasted with incremental planning. Planning for a horizon year that may be 10-, 20- or 30-years ahead avoids the inefficiency of incrementally upgrading transmission lines on a 2-, 3 or 5- year horizon. As already noted, transmission lines have a long lifetime and it makes sense to establish their utilization for a larger duration. An incremental process may require a 115 kV line to be upgraded every 5 years whereas horizon year planning can determine if a higher capacity or voltage might be a better plan.

- **Coordinated planning instead of centralized planning.** Transmission usage is no longer limited to the bulk transfer of power from large power stations to distribution load centers, but is transforming into a collector for dispersed resources located where local communities, environments and energy customers are affected. This presents many new considerations to account for in the planning process with many more stakeholders. These stakeholders may represent different jurisdictions, all of whom need to coordinate their planning efforts.

Selected Best Practices

- The integration of elements of **distribution planning** is an important extension for transmission planning. A large portion of renewable generation comes from DERs. From the transmission perspective, this could mean a net reduction in the load that the bulk system needs to serve. In many jurisdictions, DERs are backfeeding energy into local transmission, converting substations from loads to generators at various times of the day.

- **Expanded base cases.** Load level is no longer the only factor that determines the potentially worst case conditions that the grid must face. The weather-dependence of renewables and their concentration in various geographic areas of the grid can lead to extreme levels of transmission usage such as peak wind and peak solar that are not coincident with the peak load hour.
  - Some planning entities have already adopted derating of renewables in peak load planning models. This is in recognition of the unique load cycles from renewables.

Selected Best Practices

- Vetted base cases. Traditionally, the bulk power system planning entity, such as the ISO or local utility, prepare the base cases to use in the planning process. This is based on the common understanding that these entities had the most up-to-date information needed to build the models. However, changes in the resource mix and developments at the lower voltage levels have led to base cases that do not accurately reflect grid future conditions or desired outcomes. In California, the CPUC has taken the extra-ordinary step of defining the base cases for the CISO planning process. In New York, the PSC has directed the development of “unified power flow” models with input from other stakeholders such as local communities and developers.
- Creation of renewable energy zones. The confluence of available land, favorable local policies and harnessable amounts of solar and wind energy but the absence of transmission capacity points to the need to include defined development areas in the planning process. States with such zones, such as Texas’ CREZ, have seen significant growth in new renewables associated with the provision of larger amounts of transmission headroom.

Selected Best Practices

- **Storage as a transmission asset**. Storage is much more than just a generator filling in upramp headroom or a load that will utilize downramp capacity. Storage, utilized in its various forms, can help increase thermal- and voltage-limited interface capacity, delay, replace or reduce planned transmission upgrades, enable microgrids, provide ancillary services, help relieve transmission congestion, and alleviate the duck curve phenomenon. It belongs in the transmission planners' toolbox of possible solutions.

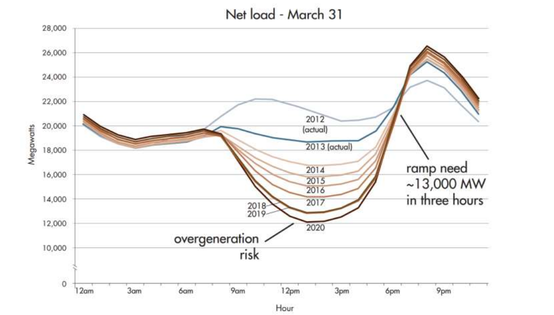


Figure 1. The CAISO duck chart

Source: CAISO 2013

- Incorporating **advanced technologies**. Using technology that has worked over the last 100 years may provide some level of confidence in the reliability of planned systems, however, this also creates a barrier against innovation and scientific advancement that have the potential for more economic and efficient grids. FERC has recognized this and is pursuing initiatives in incorporating dynamic line rating and power flow controllers into grid processes.

General Framework for Transmission Planning

- The horizon year may represent different Portfolios or Scenarios, depending on various unknowns or Uncertainties associated with the future.
- Examples of Future Uncertainties
  - Generation development – where, when and type of technology
  - Load projections and distribution level changes
  - Policy changes – local, state, regional and federal
  - Advancing transmission technology

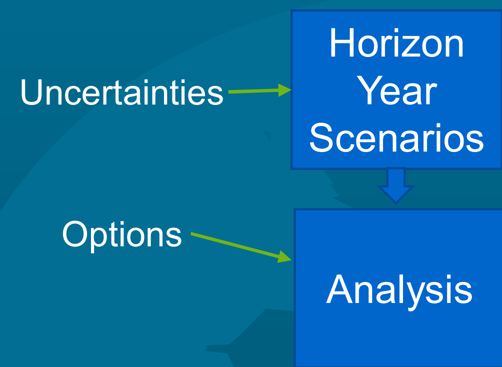
Future **Portfolios** represent the energy mix as driven by renewable energy targets and retirement objectives.

Scenarios are the various generation dispatch assignments that a planned transmission system must support for each specific Portfolio

While transmission planning processes may not use the same terminology as discussed here, they will all have similar elements to those described here.

General Framework for Transmission Planning

- Options are the choices the planner has that may be included in a transmission plan.
- Options available in the planner's toolbox:
  - Base case assumptions such as renewable headroom targets
  - Solar and wind development areas, including renewable energy zones
  - Line routes, including underground and submarine
  - Capacity, design and voltage levels of transmission lines
  - Dynamic line rating and power flow controllers; storage as a transmission asset
  - Technology: AC or DC
  - Location: land-based or offshore
  - Others: Hubs, interregional connections, offshore mesh networks
  - Other transmission facilities: transformers, PARs, SVCs, capacitors, reactors, etc.
  - Associated Costs for each Option

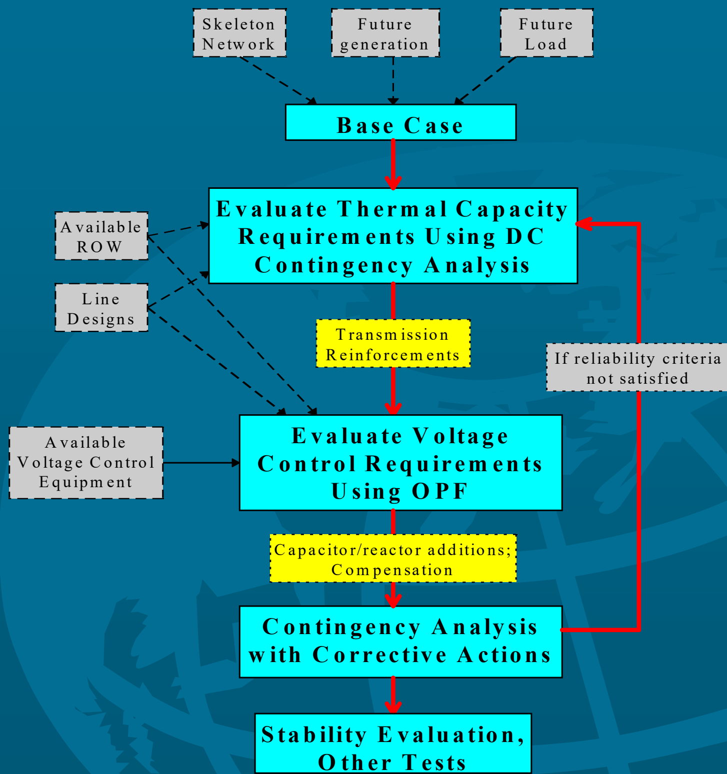


General Framework for Transmission Planning

- Standards are guidelines, rules, restrictions and criteria that the planner must follow to determine if a plan is compliant or not.
- Standards include:
  - Policy guidelines and orders
  - Local rules and laws
  - Interregional rules for energy exchange, CBM and TRM
  - Environmental restrictions such restricted areas, crossing and access limitations
  - Reliability criteria: NERC, reliability council, individual utility planning criteria

General Framework for Transmission Planning

- Technical, economic and policy analyses seek to identify components of a transmission plan
- There is a wide variety of technical and economic procedures for developing a transmission plan



Sample technical process

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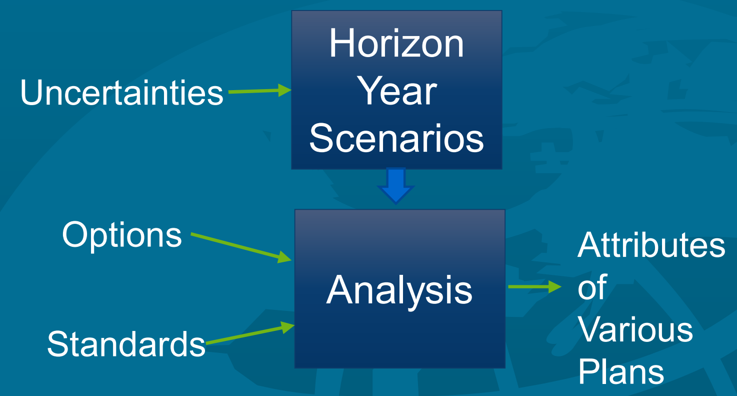
General Framework for Transmission Planning

- Analysis produces various concepts and/or preliminary plans.
- The attributes of each plan is measured
- Attributes include:
  - Capacity and energy headroom for new renewables
  - Costs such as CapEx, OpEx, upramp and downramp costs, congestion rents
  - Compliance with renewable mandates
  - Relative value of reliability
  - Curtailment or loss of load indices
  - Specific benefits to various stakeholders
  - Special features or negative components



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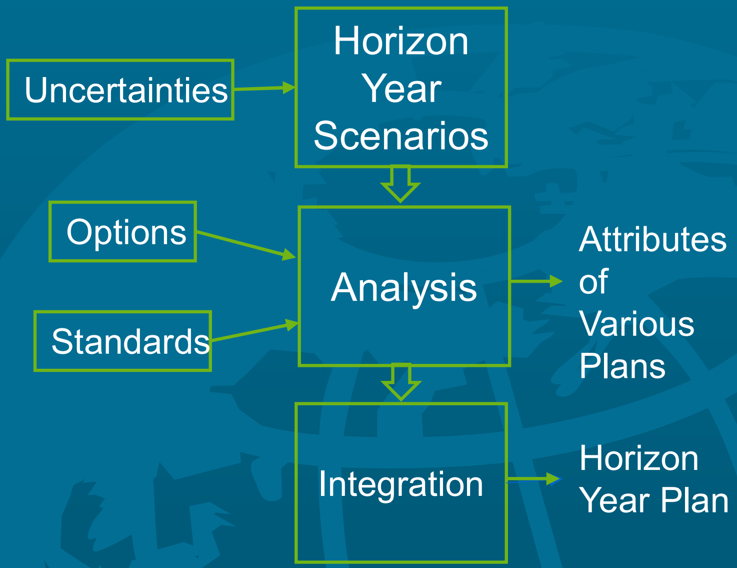
General Framework for Transmission Planning

- Integration (or Decision-making) is the process of selecting components of the transmission plan derived from multiple horizon year Scenarios. This is also where close coordination with other jurisdictions and all stakeholders takes place.
- A robust plan, ideally, supports all Scenarios. In most cases, the best option is a plan which addresses the most Scenarios.
- The plan needs flexibility (or Hedging) to address outlier Scenarios or to respond to changes in future uncertainty. Flexibility is keeping certain expansion paths open while specific uncertainties are unresolved.



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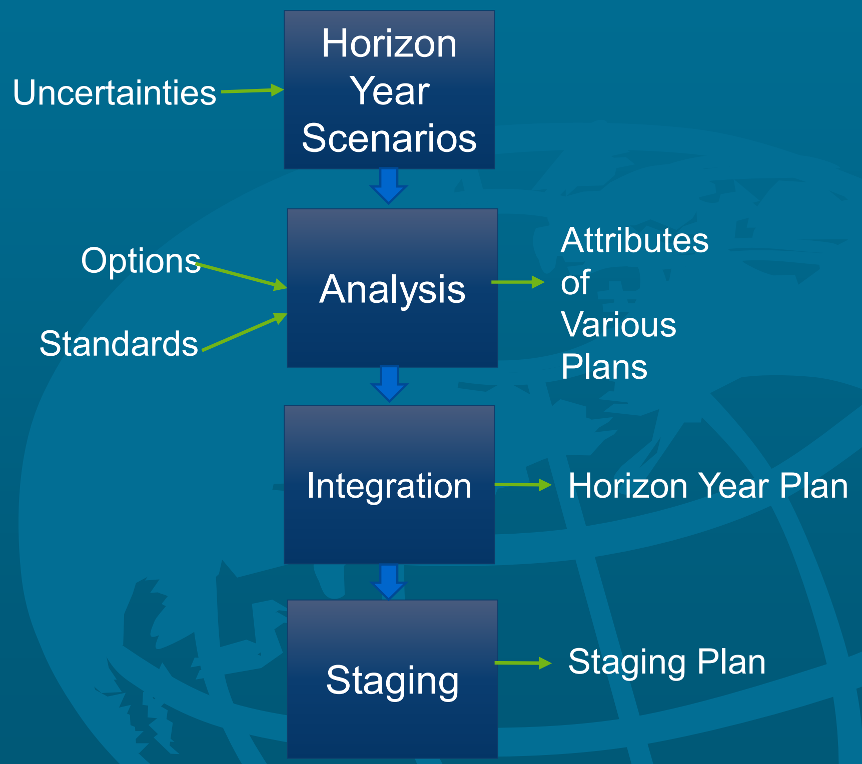
General Framework for Transmission Planning

- Staging is the process of mapping how to reach the horizon year scenarios by chronologically implementing the components of the plan.
- For example, the horizon plan says a new 345 kV line is needed. The staging plan determines under what conditions the 345 kV will be initiated and when



Takeaways

- Transmission Planning processes are evolving because transmission use is evolving. Key factors are the change in resource mix, primarily from fossil-fired to renewables, and the growth of embedded generation in distribution and lower voltage systems.
- Solar and wind generation have unique characteristics that are not captured well in present transmission planning processes which were founded on centralized, non-variable thermal power plants.
- Transmission upgrades identified through the interconnection process tend to be incremental in nature and are not consistent with transmission planning practice. The continued use of this process in place of horizon year planning results in sub-optimal transmission systems that require continuous modification.
- Transmission planning is no longer a utility-only function but requires the coordinated effort of multiple stakeholders.