Ensuring Cost-Effective Transmission in Support of a Clean Energy Transition

PREPARED BY

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PRESENTED TO

NESCOE
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Brattle

The Challenge: How to Achieve an Affordable Energy Transition

The challenge to achieving an affordable clean-energy transition is formidable:

1. Much of the (aging) existing <u>generating resources will need to be replaced</u> over the next two decades
2. Electrification and data center <u>load growth will double</u> the amount of generation supply needed (even with EE)
3. Local, regional, and interregional <u>transmission capacity will need to double or triple</u> to achieve a cost-effective outcome (as numerous studies have already shown)

More investment will be needed than can easily be provided and recovered

Unless done efficiently and cost-effectively, the size of investments and customer rate impacts will quickly exceed feasible and acceptable levels!

Nobody will be "happy" if rates start to exceed certain levels

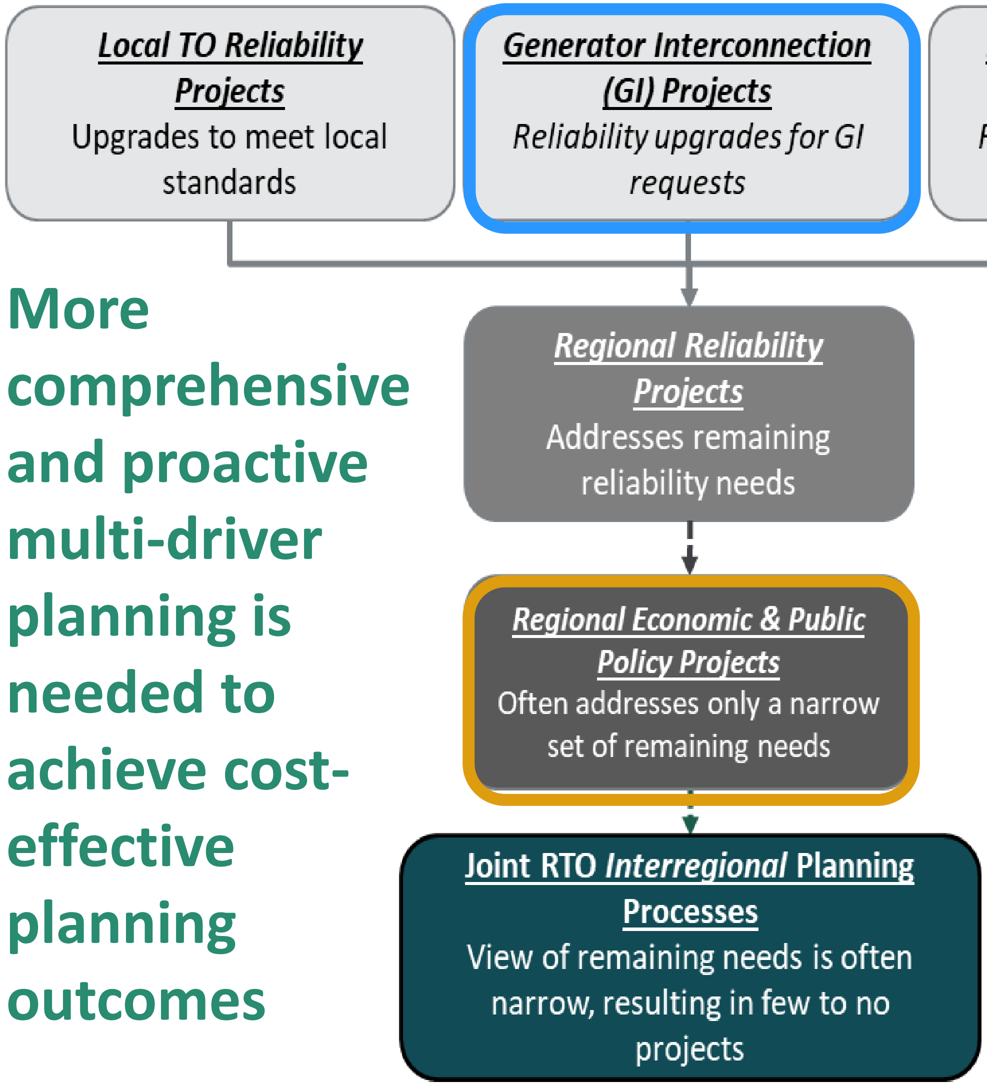
- Unaffordable rates will undermine or <u>delay policy goals</u>
- High fixed costs will create <u>uneconomic bypass</u> of existing facilities, which will further increase total costs
- Unhappy customers and regulators create <u>risk and challenges</u> for regulated companies and their investors
- Utility credit ratings will deteriorate and limit the amount of investments that can be financed

Options for achieving a more affordable energy transition

Achieving cost-effective outcomes requires a multi-faceted approach:

1. More **proactive and holistic transmission planning**
   - Multi-driver/value planning (incl. for generator interconnection) to find lowest-total-cost solutions
   - Least regrets planning to mitigate risk and costs of both overbuilding and undersizing
2. "**Loading order**" for transmission planning that prioritizes lower cost/impact options
   - Optimize existing grid → upsize existing lines → add new lines
3. **Cost control incentives**
   - Broad-based PBR, targeted incentives, soft/hard caps, shared savings/overruns
4. **Competitive solicitations**
   - Where possible and practical; with added cost-control incentives
5. **Efficiency and demand flexibility**
   - To reduce transmission, distribution, generation, and resource-adequacy costs

Proactive + Holistic Planning: to reduce the inefficiencies of "siloed" transmission planning processes



More comprehensive and proactive multi-driver planning is needed to achieve cost-effective planning outcomes

These solely reliability-driven processes account for > 90% of all transmission investments

- None involve any assessments of economic benefits (i.e., cost savings offered by the new transmission)

Incremental generation interconnection has become the primary tool (and efficiency barrier) to support public policy goals

Planning for economic & public-policy needs results in less than 10% of all U.S. transmission investments

Interregional planning processes are large ineffective

- Essentially no major interregional transmission projects have been planned and built in the last decade
- Numerous national studies show that more interregional transmission is needed to reduce total system costs

See: DeLosa, Pfeifenberger, Joskow, Regulation of Access, Pricing, and Planning of High Voltage Transmission in the US, MIT-CEEPR, March 7, 2024.

More proactive planning will have to become business as usual

The benefits of proactive planning increase for planning processes that:

1. Consider all transmission needs over longer time frames (i.e., two decade of already known or likely needs for generator interconnection, local and regional reliability, economic benefits, and public policies, as opposed to need at a time)
2. Use proactive multi-value planning processes to address both urgent near-term needs and long-term needs
3. Reduce the scope of network upgrades triggered by generator interconnection through more proactive and holistic transmission planning and improve generator interconnection study criteria
4. Look beyond regional seams to identify more cost-effective interregional solutions to the range of identified transmission needs (and minimize the scope of and uncertainties associated with "affected system studies")
5. Rely on advanced transmission technologies to address identified needs
6. Utilize pragmatic cost allocations that are roughly commensurate with benefits received

Integrating generator interconnection and replacements into comprehensive, more proactive transmission planning processes will be important

- More cost-effective, holistic solutions can be identified to address the wide range of future needs
- The costs and time required to interconnect the large number of resources necessary to meet clean-energy goals can be reduced dramatically

Options for interconnecting resources more quickly and efficiently

With FERC Order 2023 guidance and emerging best practices from other regions, the following measures can add resources more quickly and cost-effectively:

1. Implement fast-track process for sharing and transfers of existing POIs
2. Identify existing “headroom” at possible POIs
3. Fast-track new POIs for “first-ready” projects
4. Allow for GETs and (simple) RAS/SPS to address interconnection needs
5. Simplify ERIS (energy-only) interconnections with option to upgrade to NRIS (capacity) later
6. Proactively and holistically plan for long-term transmission needs
7. Speed up state & local permitting for projects with signed interconnection service agreements (PJM blog: 44+ GW with ISAs yet only 2 GW brought online in 2022)

More more detail see: Are Firm Capacity Requirements Outpacing Replacements?, January 25, 2024

Risk mitigation through better "Least-Regrets" planning

Planning processes need to consider the risk-mitigation and insurance value of transmission infrastructure:

- Given that it can take a decade to develop new transmission, delaying investment can easily **limit future options** and result in a **higher-cost, higher-risk** overall outcomes
  - "Wait and see" approaches will limit options, so can be more costly in the long term
  - Address both short- and long-term uncertainties more flexibly and comprehensively
  - Develop more flexible solutions that can respond more cost-effectively to uncertain long-term needs (example: single circuit lines on double-circuit towers; modular/expandable designs)
- **"Least regrets" planning** needs to focus on minimize the risk of both under- and overinvesting
  - Scenario-based planning to minimize possible regrets … must focus <u>not only on</u> (1) identifying projects that are beneficial under most cases; <u>but also</u> consider (2) the many "regrettable" high-cost outcomes that could result in some scenarios if transmission investments are not made or undersized
- Taking probability-weighted averages is insufficient as it assumes risk neutrality and cannot distinguish between plans with higher/lower risk distributions

A “Loading Order” is needed to double or triple transmission capacity more quickly and cost-effectively (with lower impacts)

1. Advanced, grid enhancing technologies

- Dynamic line ratings
- Flow control devices
- Topology optimization
- Grid-optimized DER/storage
- Remedial action schemes
- Grid-forming inverters

3. New transmission

- Highway/railroad corridors
- ROW-efficient AC designs
- HVDC transmission
- Submarine/undergound
- New greenfield overhead

2. Upgrades of existing lines

- Advanced conductors
- Rebuild aging lines at higher voltage
- Conversions to HVDC

Examples:

Priority order required by the German “NOVA Principle”

MA CETWG Report: Loading Order and ATT/GETs recommendations

Advanced Grid Technologies: Fast and cost-effective solutions

Advanced and grid-enhancing transmission (GET) technologies can (1) significantly and quickly increase the capability of the existing grid, (2) offer low-cost solutions to address near-term reliability needs, and (3) also make new transmission more valuable and cost effective in the long-term

- Value proposition: more visibility of actual grid capability; shift flows to underutilized portions of the grid
- Increasingly well-tested and commercially-available technologies include: dynamic line rating, smart wires and flow control devices, grid-optimized storage, topology optimization, advanced conductors
- Can be deployed quickly to integrate renewables on the existing grid (see Chapter III of NY Power Grid Study)
- Brattle case study in SPP: DLR, topology optimization, and advanced power-flow controls can integrate 2,670 MW of renewable generation for only $90 million
- See also discussion in MA CETWG report (Section 7), CurrENT's report, topology optimization case studies

Consideration of GETs needs to be expanded beyond addressing operational and congestion needs– GETs should be part of the standard set of available solutions to address generation interconnection and both short- and long-term transmission planning needs

- As low-cost solutions to address reliability needs identified in generation interconnection and near-term planning
- In long-term multi-value planning to make new transmission more cost effective and valuable, reducing system-wide costs

Improve incentives to control project costs and deploy lower-cost solutions

Expanded use of cost-control incentives is advisable. Examples include:

- **Broad-based** performance-based ratemaking (PBR),
  - UK incentives for transmission providers (for both investments and operations) under "RIIO"
  - Australian incentive schemes for networks: efficiency benefits sharing scheme (EBSS), capital expenditure sharing scheme (CESS), and service target performance incentive scheme (STPIS)
- **Project-specific** cost-control and targeted cost-sharing incentives
  - Hard or soft cost caps (with adjustments for some uncontrollable factors)
    - Examples: NJ SAA Evaluation Report, Appendix E
  - Shared savings incentives for project cost (and schedule) under/overruns
    - Australian 70/30 sharing mechanism (for realized vs. forecast costs) under CESS
    - NY PPTN: at least 80/20 sharing strongly encouraged (NYISO tariff at 31.4.5.1.8.3, FERC order, recent award)
    - Proposed shared savings incentives for GETs (e.g., link1, link2)
  - The project-specific "baselines" of expected costs can be: (1) competitive bids, (2) independent cost estimates, or (3) menu-based "revealed expectations" mechanisms
- **Cost reviews** of significant overruns
  - Australian targeted ex-post review process

Competitive Procurements: Innovation and reduced costs

FERC's Order No. 1000 intended to promote "more efficient or cost-effective transmission development" through competitive procurements (creating much controversy)

Solutions-Based Procurements | **Project-Based Procurements**

Transmission Needs Assessment → **Solutions Solicited, Proposed, and Selected** → **Projects Solicited, Offered and Selected**

Developers compete to provide, finance, build, own, and operate innovative solutions to meet specified needs

- Planning entities identify needs and solicit innovative solutions
- Planning entities select preferred solution; selected developers finance, build, own, and operate projects
- **Examples: PJM, NYISO, ISO-NE, UK**

Developers compete to finance, build, own, and operate pre-specified projects

- Planning entities identify need and specify solution; solicit bids for the specified project
- Planning entities select developer to finance, construct, and own the projects based on factors including bid prices
- **Examples: CAISO, MISO, SPP, Brazil, Alberta, Ontario**

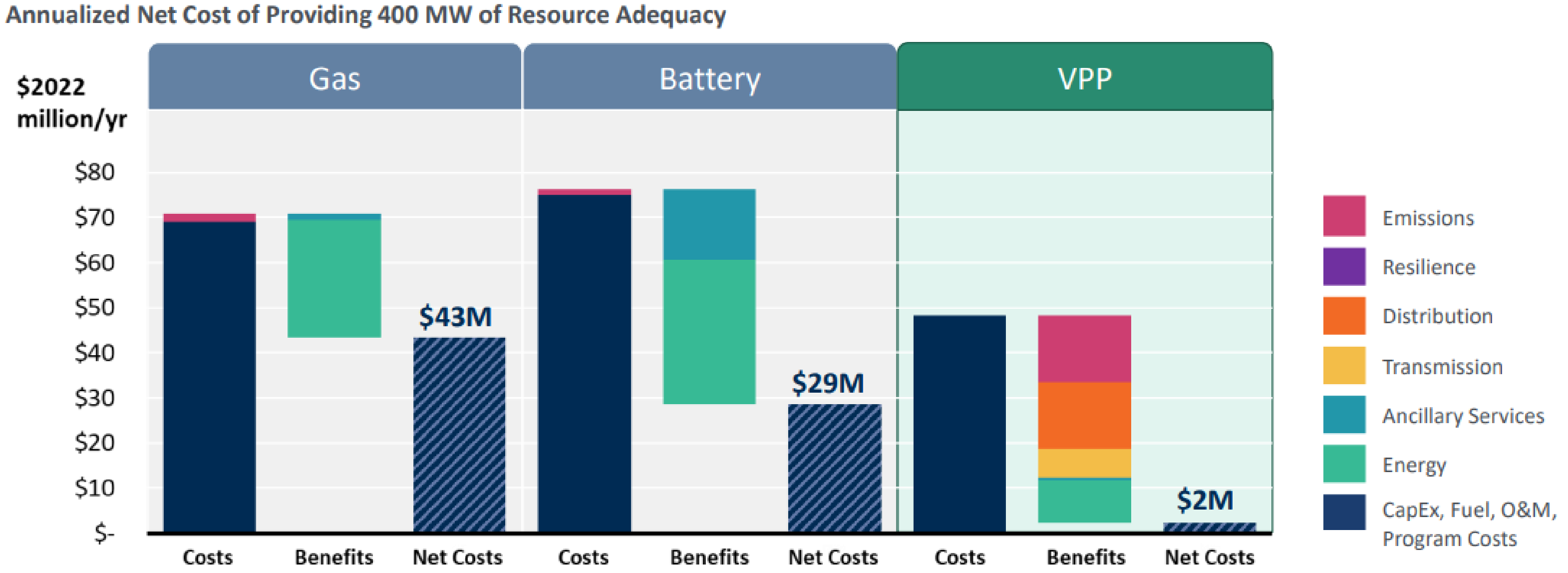
Several studies of competitive procurements in the U.S., Canada, U.K., and Brazil show that competitive solicitations can yield **more innovative solutions** and **cost savings of 20-30%**. Yet, less than 5% of U.S. projects are subject to competitive procurements

Efficiency and demand flexibility to reduce G+T+D costs

Electrification is quickly increasing electricity demand and system peak loads … and offers substantial opportunities to more cost-effectively meet system needs

- Most electrification demand is flexible (suitable for Virtual Power Plants or VPPs)
  - Examples: Electric vehicles (including V2G), building HVAC, thermal storage, solar+storage, data centers, H2
- Many electrification loads and distributed energy resources (DERs) are highly controllable
  - RMI: 60 GW of dispatchable VPPs can be developed by 2030 to provide RA and flexibility/operational reliability

Example: VPPs offer resource adequacy at (1) significantly lower cost and (2) without delays in generator interconnection



Source: Hledik and Peters, Real Reliability: The Value of Virtual Power (Brattle, May 2023)

Thank You!

Additional Slides

About the Speakers

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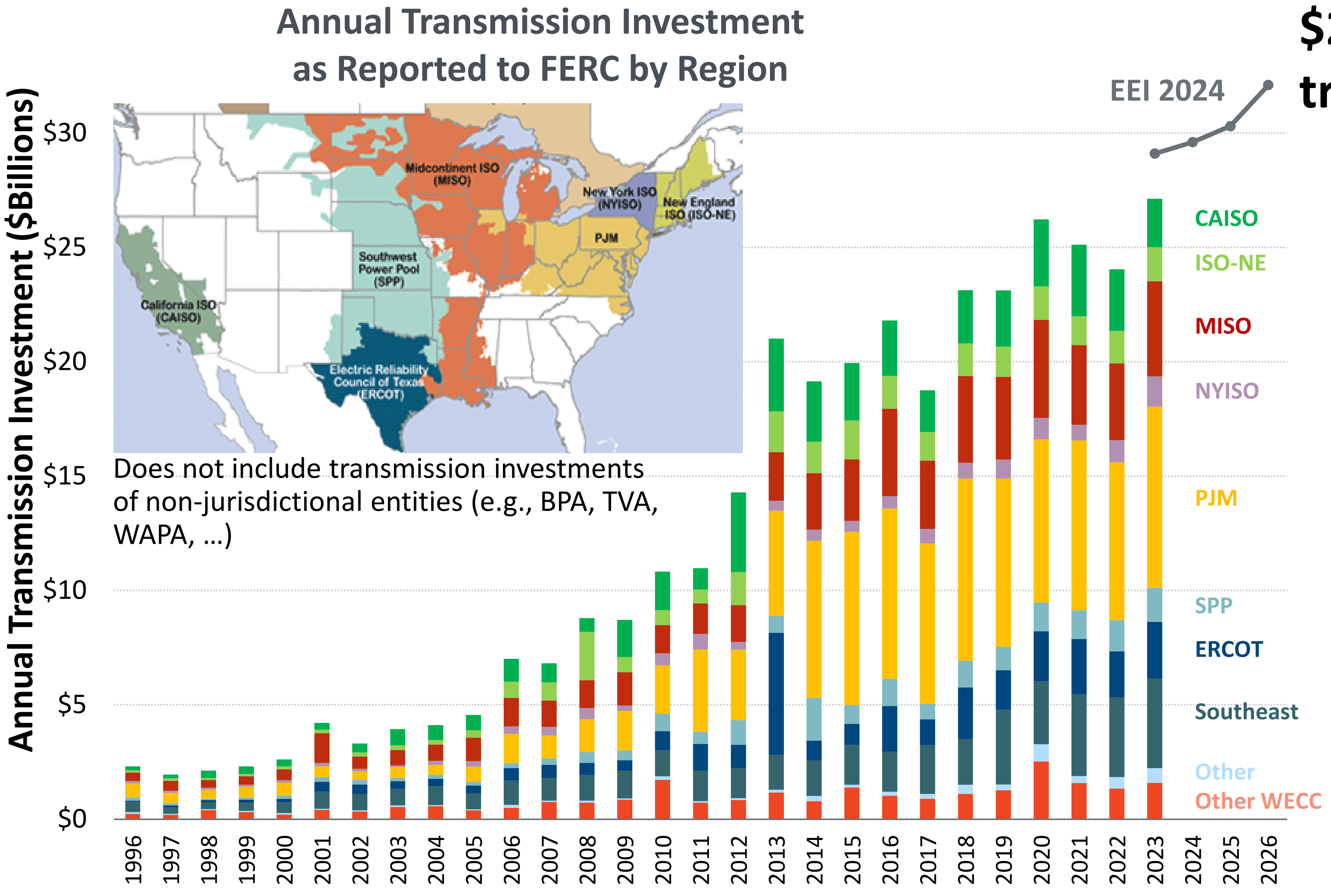
(webbio and publications)

Johannes (Hannes) Pfeifenberger, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT's Center for Energy and Environmental Policy Research (CEEPR), a former Senior Fellow at Boston University's Institute of Sustainable Energy (BU-ISE), a IEEE Senior Member, and currently serves as an advisor to research initiatives by the U.S. Department of Energy, the National Labs, and the Energy Systems Integration Group (ESIG).

Hannes specializes in wholesale power markets and transmission. He has analyzed transmission needs, transmission benefits and costs, transmission cost allocations, and renewable generation interconnection challenges for independent system operators, transmission companies, generation developers, public power companies, industry groups, and regulatory agencies across North America. He has worked on transmission matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, and Canada and has analyzed offshore-wind transmission challenges in New York, New England, and New Jersey.

He received an M.A. in Economics and Finance from Brandeis University's International Business School and an M.S. and B.S. ("Diplom Ingenieur") in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

Annual U.S. Transmission Investments 1996-2023

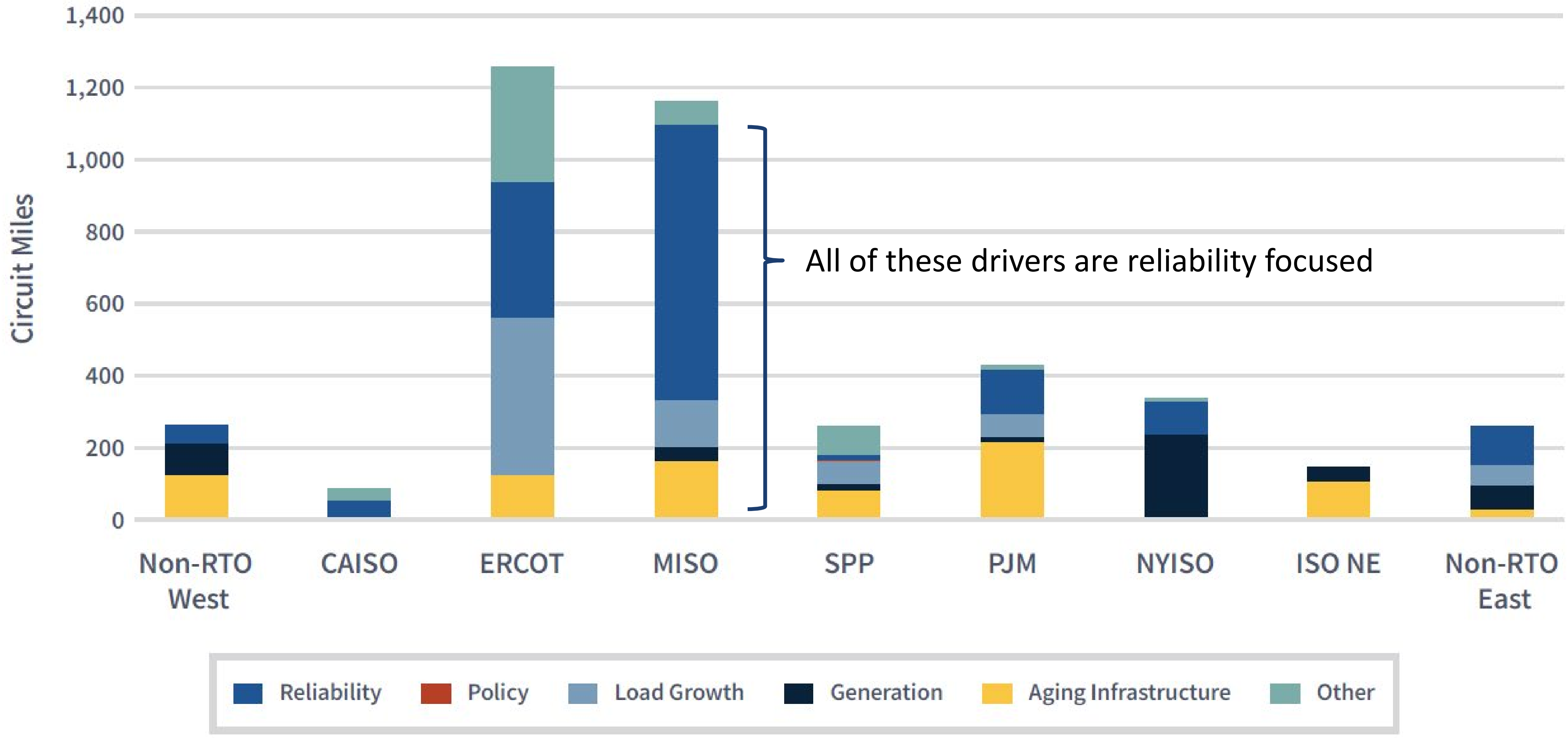


Sources: The Brattle Group analysis of FERC Form 1 Data; EEI "Historical and Projected Transmission Investment" report.

$25+ billion in annual U.S. transmission investments, but:

- More than 90% of it justified solely based on reliability needs without benefit-cost analysis
  - About 50% solely based on “local” utility criteria (without going through regional planning processes)
  - The rest justified by regional reliability and generation interconnection needs
- While significant experience with transmission benefit-cost analyses exists, very few projects are justified based on economics to yield overall cost savings
- FERC Order 1920 may change that

2023 Transmission Investments by Driver



Source: FERC Staff Report: 2023 State of the Markets (March 21, 2024), Figure 15 (based on C3 Group data)

Proactive, Multi-Driver, Scenario-based Planning

Experience with <u>proven transmission planning practices</u> show they reduce total costs and mitigate risks by comprehensively addressing both near- and long-term needs:

1. **<u>Proactively plan</u> for all future generation- and load-serving needs** by incorporating realistic projections of the anticipated generation mix and locations, public policy mandates, load levels, and load profiles over the lifespan of the transmission investments
2. **<u>Use multi-driver planning</u> and account for the <u>full range of transmission projects' benefits</u>** and to comprehensively identify investments that cost-effectively address all categories of needs and benefits
3. **<u>Address uncertainties</u> and high-stress grid conditions explicitly through <u>scenario-based planning</u>** that takes into account a broad range of plausible long-term futures as well as real-world system conditions, including challenging and extreme events
4. **Use comprehensive transmission <u>network portfolios</u>** to address system needs and cost allocation more efficiently and less contentiously than under a single-driver, project-by-project approach
5. **Jointly <u>plan inter-regionally</u> across neighboring systems** to recognize regional interdependence, increase system resilience, and take full advantage of interregional scale economics and geographic diversification benefits.

See: Brattle and GridStrategies, Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, October 2021.

Examples of Proactive, Scenario-based Planning Processes

Although still rarely used, significant experience exists with proactive, multi-driver (multi-benefit), scenario- and portfolio-based transmission planning:

	Proactive Planning	Multi-Benefit	Scenario-Based	Portfolio-Based	Interregional Transmission
CAISO TEAM (2004)[146]	✓	✓	✓		
ATC Paddock-Rockdale (2007)[147]	✓	✓	✓		
ERCOT CREZ (2008)[148]	✓			✓	
MISO RGOS (2010)[149]	✓	✓		✓	
EIPC (2010-2013)[150]	✓		✓	✓	✓
PJM renewable integration study (2014)[151]	✓		✓	✓	
NYISO PPTPP (2019)[152]	✓	✓	✓	✓	
ERCOT LTSA (2020)[153]	✓		✓		
SPP ITP Process (2020)[154]		✓		✓	
PJM Offshore Tx Study (2021)[155]	✓		✓	✓	
MISO RIIA (2021)[156]	✓	✓	✓	✓	
Australian Examples:					
- AEMO ISP (2020)[157]	✓	✓	✓	✓	✓
- Transgrid Energy Vision (2021)[158]	✓	✓	✓	✓	✓

(See specific examples for SPP, MISO, CAISO, AEMO, and ENTSO-E in additional slides)

Source: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs (brattle.com)

What is Proactive, Scenario-Based, Long-Term Planning?

Scenario-based planning is a process first developed in the 1940s and 1950s as a tool for integrating uncertainties into long-term strategic planning:

- Used by Shell with great success since the 1970s for long-term planning under large uncertainties
- **Assists planners to think, in advance, about the many ways the future may unfold and how to respond effectively and flexibly as the future becomes reality**
- Ranks among the top-ten management tools in the world today
- Scenario = one fully-defined, plausible view of what the future may look like

Scenario-based planning is a multi-step process:

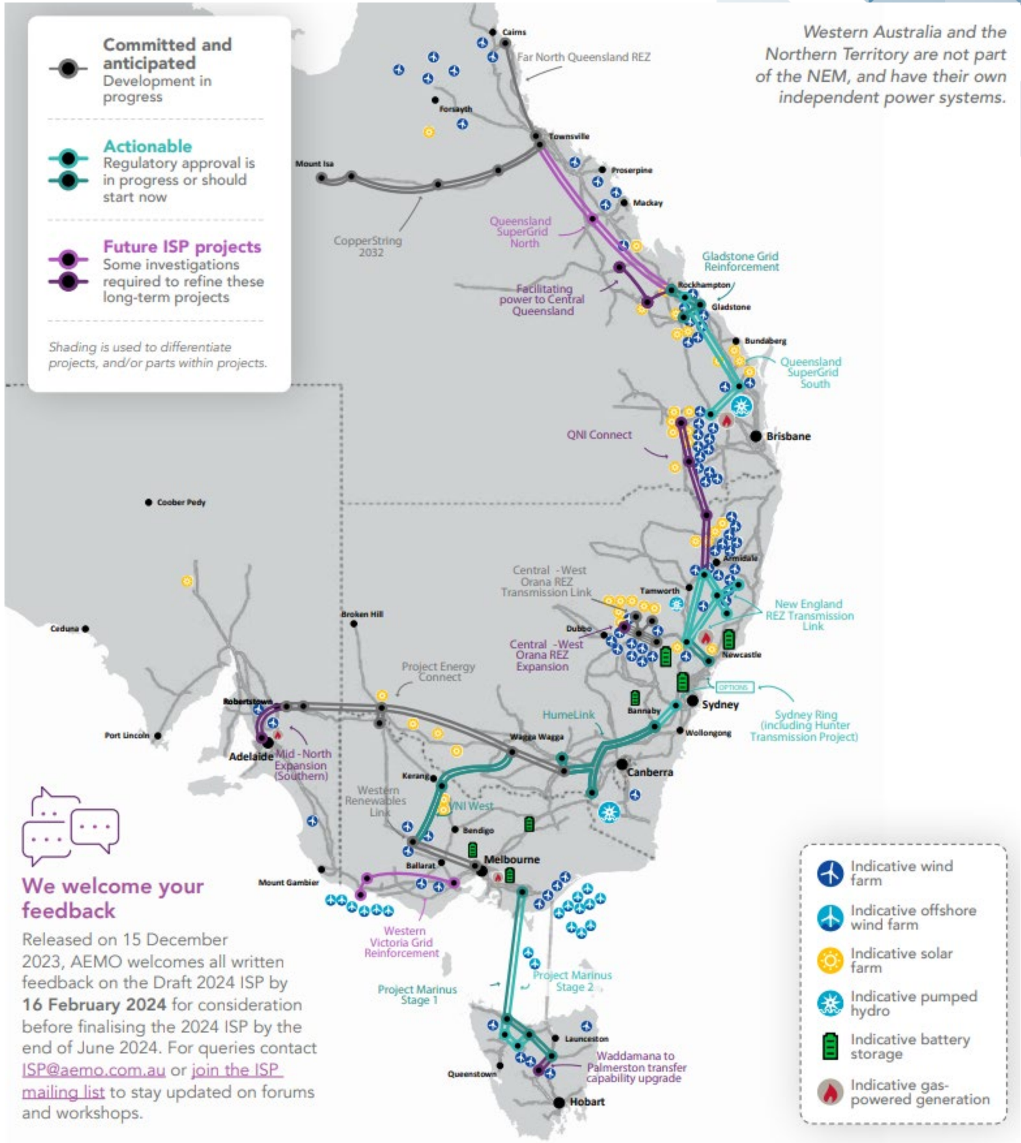
1. Define scenarios of plausible futures by scanning the current reality, trends and forecasts, uncertainties, and important internal and external drivers
2. Develop a series of plans (initiatives, projects, policies, tactics) that support a certain scenario, work well in multiple scenarios, or are flexible and robust across all scenarios
3. Implement preferred plan and define indicators to alert planners that a certain future is likely to occur, so they can take action (e.g., change course to address the new developments)

See also, e.g., Living in the Futures (hbr.org), Scenario Planning-A Review of the Literature.PDF (mit.edu)

Example 1: Australian Integrated System Plan (ISP)

The Australian Energy Market Operator (AEMO) integrated planning process is "best in class":

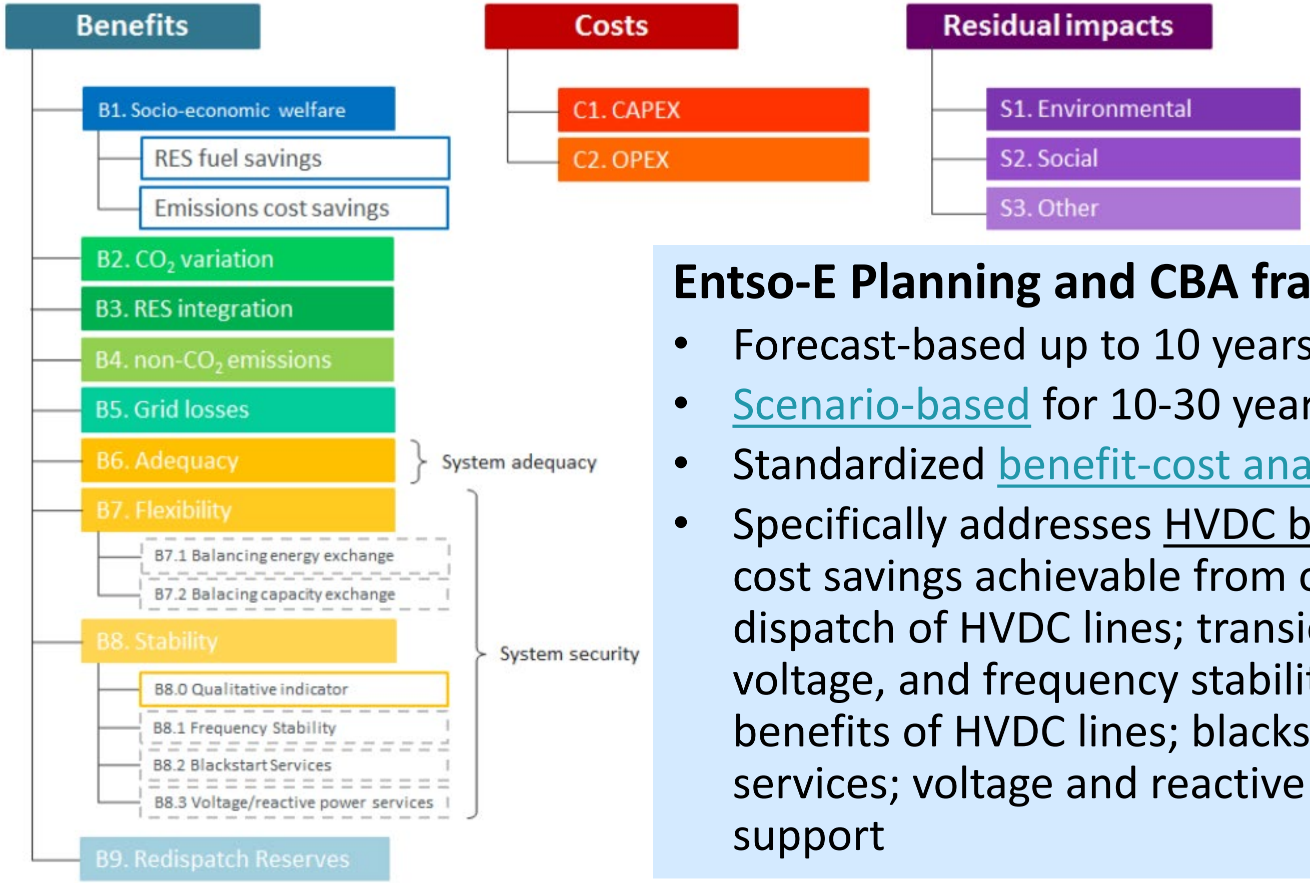
- Clearly-specified methodology (link) produces updated plans every two years with extensive stakeholder consultations (see Draft 2024 ISP)
  - Scenario-based analysis explicitly considers long-term uncertainties over next 30 years (link)
  - Plans distinguish: (1) actionable projects for which the need is certain enough now to move forward; and (2) future projects that are likely needed at some point
  - Least regrets planning values optionality that can be exercised if/when needed (e.g., projects that can be built/expanded in stages; or undertaking "early works" to develop shovel-ready projects that can be constructed quickly in the future)
- Guidelines for cost-benefit framework, forecasting, and "investment tests" from the Australian Energy Regulator (AER) make AEMO plans actionable (link)



Source: AEMO | Draft 2024 ISP Consultation

Example 2: European 10-year Network Development Plans

ENTSO-E: Standardized Multi-value Benefit-Cost Analysis Framework for EU-wide Transmission Planning (incl. HVDC)

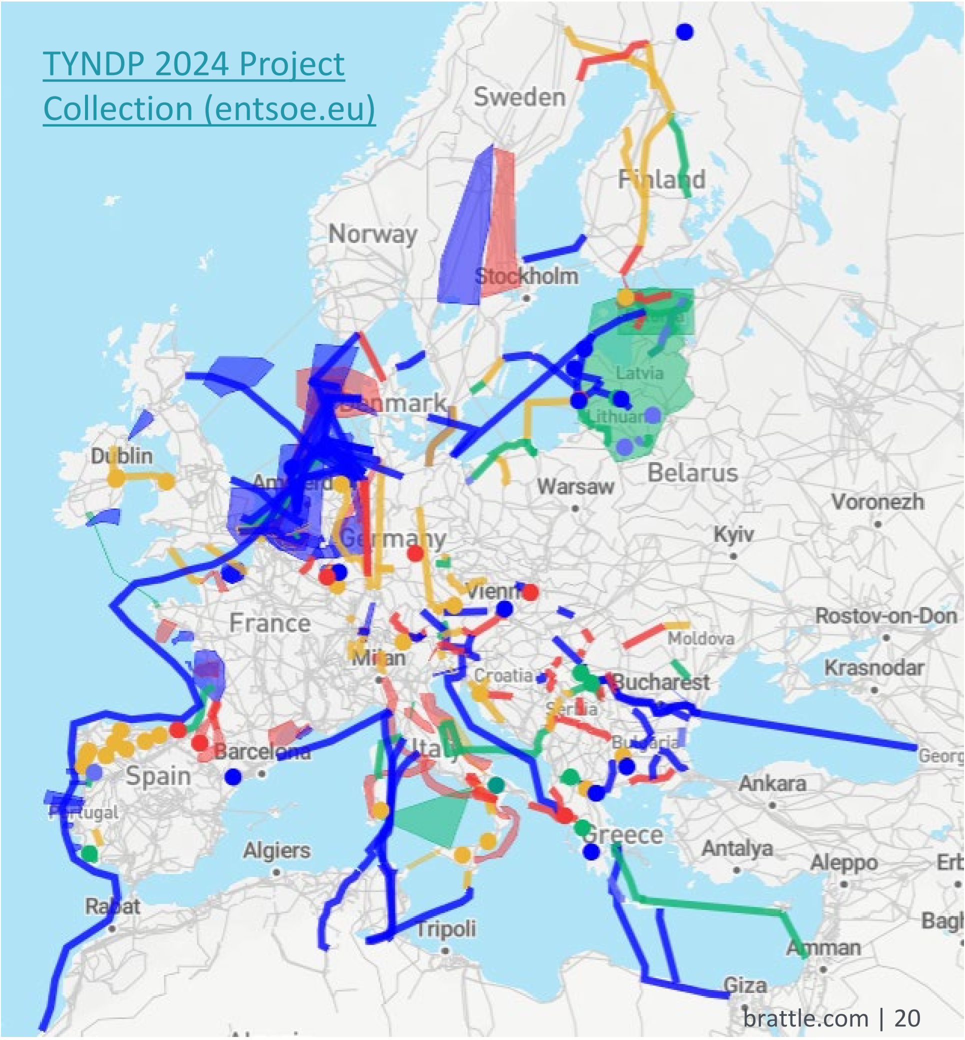


Entso-E Planning and CBA framework

- Forecast-based up to 10 years
- Scenario-based for 10-30 years
- Standardized benefit-cost analysis
- Specifically addresses HVDC benefits: cost savings achievable from optimized dispatch of HVDC lines; transient, voltage, and frequency stability benefits of HVDC lines; blackstart services; voltage and reactive power support

Source: ENTSO-e, *4th ENTSO-e Guideline for Cost Benefit Analysis of Grid Development Projects*, Oct 18, 2023, Figure 8; TYNDP 2024 Implementation Guidelines, Mar 4, 2024.
For a summary of the ENSTO-e framework, incl. HVDC, see pp. 77-80 here.

10-Year Network Development Plan (TYNDP) to Evaluate 176 Transmission, 33 Storage Projects



Example 3: MISO Long-Term Transmission Planning (LRTP)

Scenario-based LRTP ➔ Several tranches of "least regrets" portfolios of multi-value transmission projects (MVPs)

MISO 2022 LRTP results

- Tranche 1: $10 billion portfolio of proposed new 345 kV projects for its Midwestern footprint
- **Supports interconnection of 53,000 MW of renewable resources**
- **Reduces other costs by $37-70 billion**
- Portfolio of beneficial projects designed to benefit each zone within MISO's Midwest Subregion
- Postage-stamp cost allocation within MISO's Midwest Subregion

MISO is currently in the process of finalizing $23 billion of Tranche 2 projects (link)

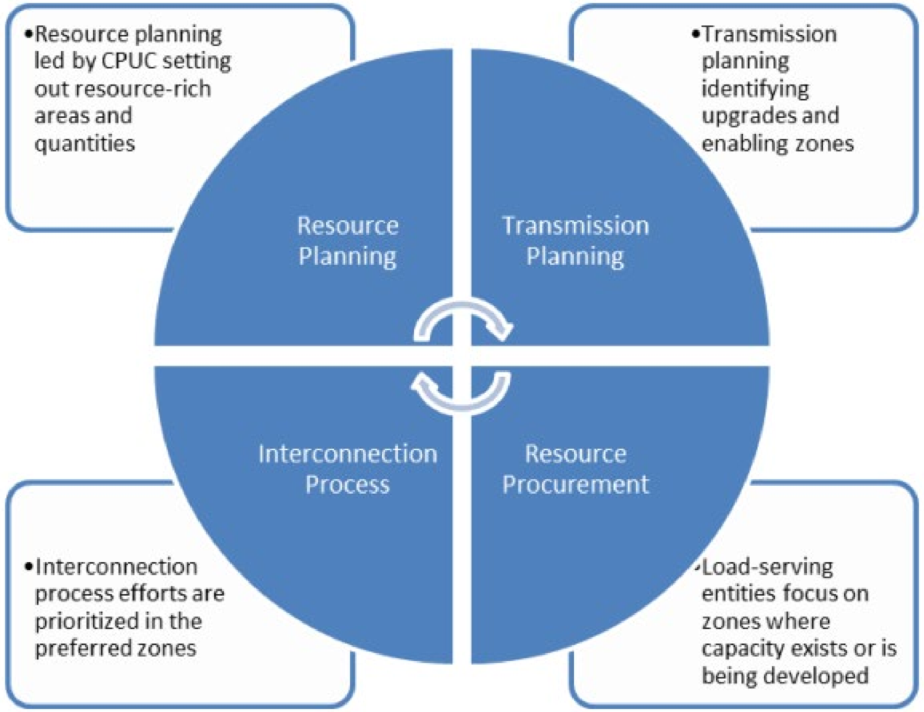
MISO 2022 LRTP, Tranche 1 Projects

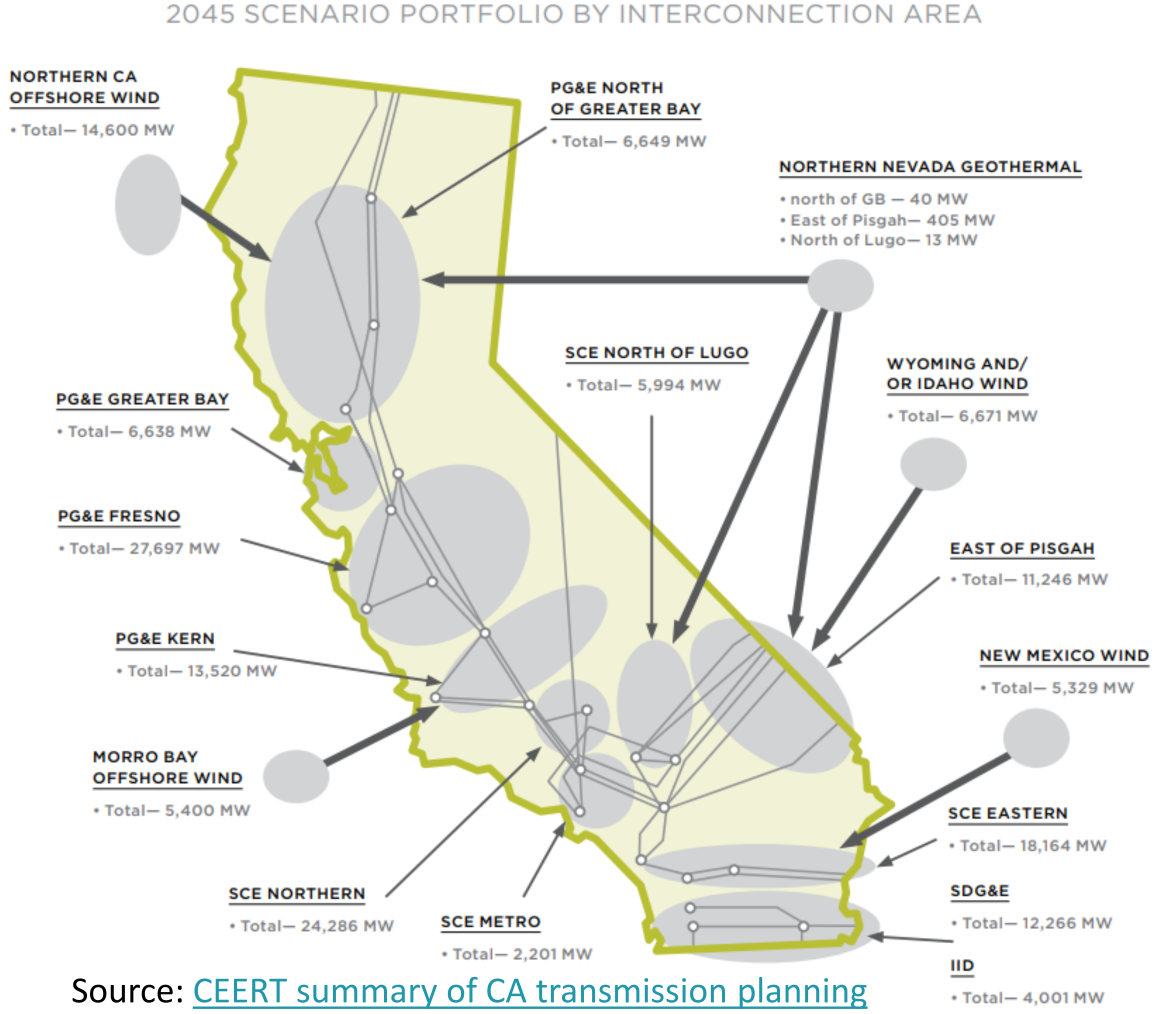
Source: 3-29-22 LRTP Presentation (misoenergy.org)

Example 4: California's Transmission Planning Process (TPP)

California's TPP combines (1) scenario-based, zonal resource development outlooks prepared by state agencies with (2) the planning and procurement of transmission solutions by the California ISO

- See overview and board-approved 2022-2023 Plan
- Improved generator interconnection process (link) offers substantial headroom





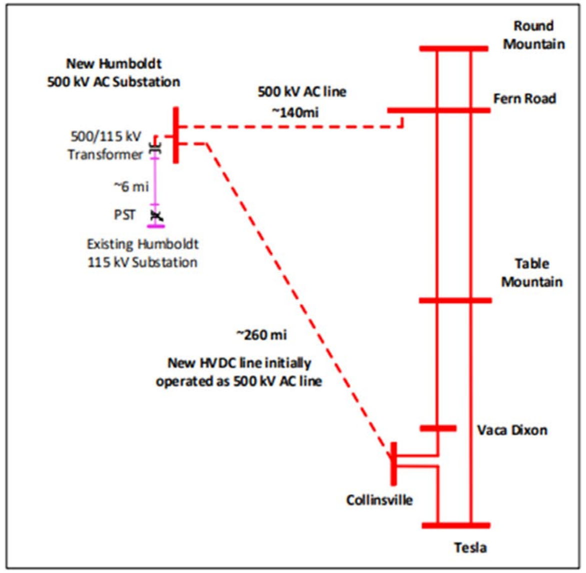
Source: CEERT summary of CA transmission planning

Example 4: California's Transmission Planning Process (TPP)

CAISO's 2023-24 TPP also includes this expandable plan to create an (onshore) point of interconnection (POI) for 1,600 MW of north-coast offshore wind, which can easily be expanded to 3,200 MW and up to 8,000 MW.

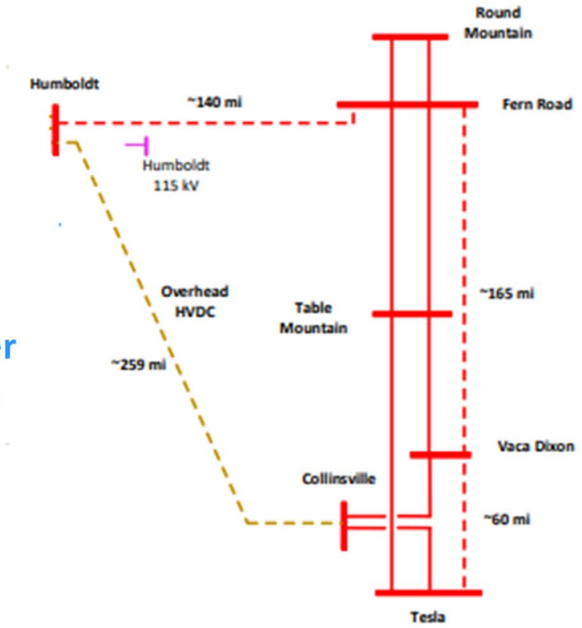
- Uses HVDC-ready 500 kV AC line with ROW for two HVDC lines

Phase 1: Base Case Plan
(1,607 MW)



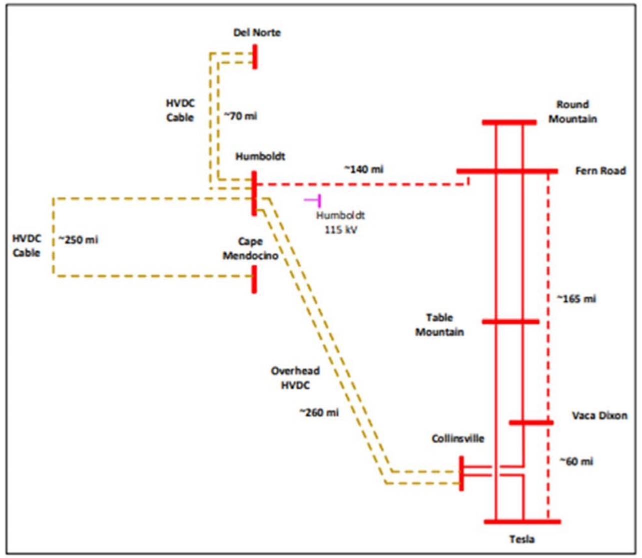
Add DC converter stations to each end of the line

Phase 2: DC Conversion
(3,100 – 3,300 MW?)



Add a second HVDC line

Phase 3: Expanded Plan (Option B)
(8,045 MW)

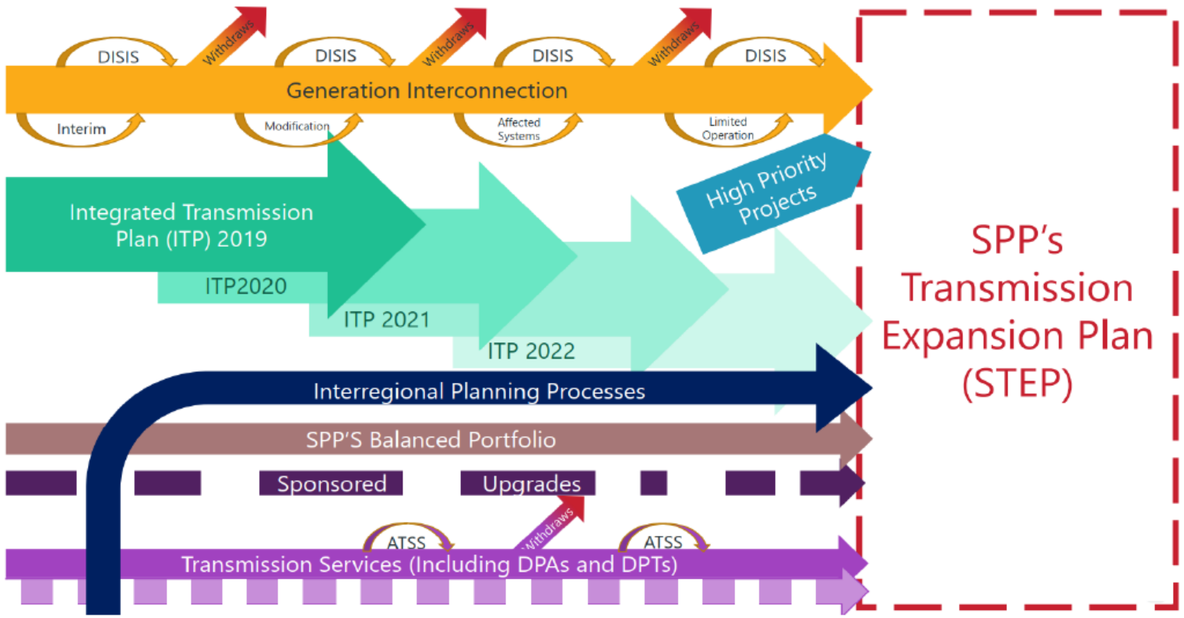


Source: CAISO board-approved 2023-2024 Transmission Plan (Sensitivity Case Plans A1, A2, and B)

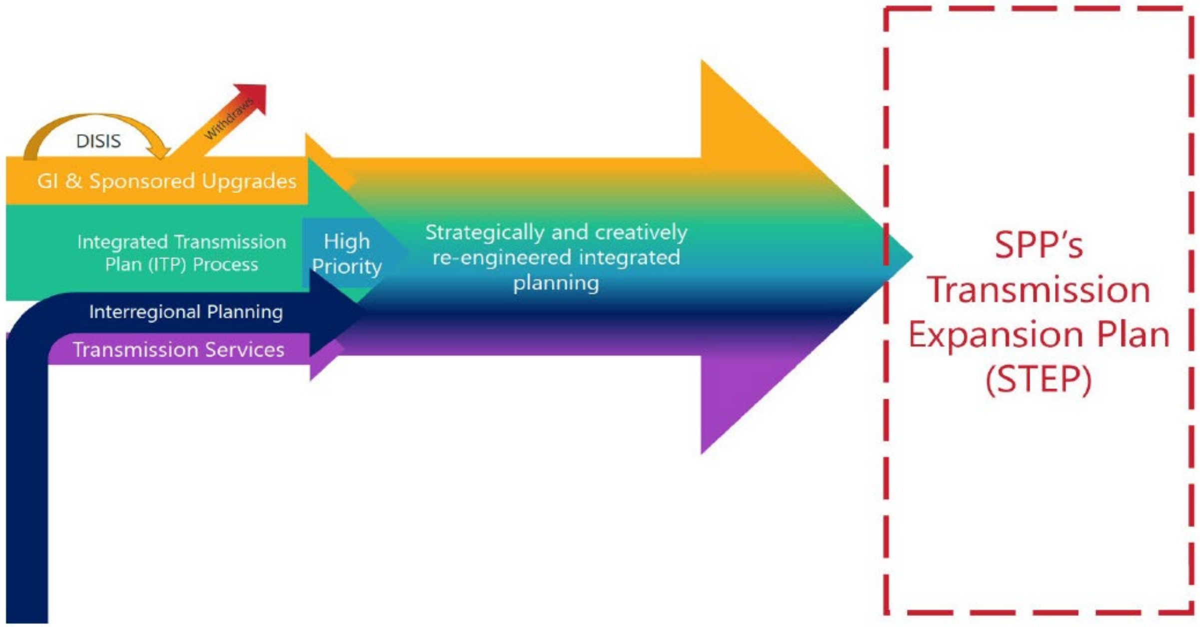
Example 5: SPP's Proposed Consolidated Planning Process (CPP)

The Southwest Power Pool (SPP) is working on consolidating its several siloed planning processes (e.g., for generator interconnection, integrated regional transmission, transmission service requests and interregion) into a single holistic process:

Current Planning Process



Proposed Consolidated Planning Process



Source: SPP, Strategic and Creative Re-Engineering of Integrated Planning Team (SCRIPT), CPP Task Force, Dec 13, 2021

Improving Generator Interconnection Studies and Planning

U.S. generator interconnection processes received poor grades. Improving them requires addressing five elements of the interconnection processes:

1. **GI Process and Queue Management:** individual vs. cluster studies, type of studies and contractual agreements, readiness criteria, financial deposits, study and restudy sequences, etc.
2. **GI Scope and "Handoff" to Regional Transmission Planning:** are major ("deep") network upgrades triggered by incremental generation interconnection requests or handled proactively and comprehensively through regional transmission planning?
3. **GI Study Approach and Criteria:** study assumptions, modeling approaches, and specific criteria differ significantly across regions (e.g., firm/non-firm study differences, injection levels studied, are generation redispatch opportunities and "remedial action schemes" considered?)
4. **Selecting Solutions to Address the Identified Criteria Violations:** most regions select only traditional transmission upgrades to address criteria violations; grid-enhancing technologies (such as power-flow-control devices or dynamic line ratings) often are not seriously considered and accepted
5. **Cost Allocation:** most U.S. regions require the interconnecting generator (or group of generators) to pay for all upgrades identified, even though (a) there may be significant regional benefits to loads and other market participants and (b) more cost effective (multi-value) regional solutions may exist

Options for Improving the Generator Interconnection Process

Reducing the scope of network upgrades triggered by generator interconnections is necessary to both accelerate and lower the cost of renewable integration:

- Attractive: UK "Connect and Manage" (replaced prior "Invest and Connect")
  - Similar to ERCOT; reduced lead times by 5 years; network constraints addressed later (e.g., with congestion management) https://www.gov.uk/guidance/electricity-network-delivery-and-access#connect-and-manage
- ERCOT's generation interconnection process is perhaps most effective in the U.S.
  - Efficient handoff of study roles by ERCOT and Transmission Owners limits restudy needs
  - Projects can be developed and interconnected within 2-3 years; in other regions, the interconnection study process itself may take longer than that
  - Upgrades focused only on local interconnection needs and are recovered through postage stamp
  - Network constraints managed through market dispatch – which imposes high congestion and curtailment risks on interconnecting generators … in part due to ERCOT's insufficiently proactive multi-value grid planning
  - See Enel working-paper.pdf (enelgreenpower.com) [Note: Brattle was not involved]

Generation interconnection based on "connect and manage" when combined with proactive transmission planning offers more timely and cost-effective solutions if:

- Near-term needs are quickly addressed through multi-value planning (beyond reliability)
- Long-term needs are proactively and comprehensively addressed through scenario-based planning

1. Fast-track Sharing and Transfers of Existing POIs

Implement new fast-track process for sharing and transferring existing POIs to bypass long interconnection queue for new POIs

- Fast-track sharing of existing POIs (both surplus interconnection capacity & sharing of energy)
- Fast-track the transfers of existing POIs (e.g., POIs of retiring plants; POIs build through SAA)

Why?

- PJM has 40+ GW of existing POIs (with CIRs) at retiring plants! … most of which are in attractive locations for new storage, renewables (e.g., as noted in the ICC draft REAP report), and natural gas plants
 (Example: client rejected new solar+storage bid at retiring fossil plant because getting ISA would take 5-6 years)
- More quickly assign POIs built under State Agreement Approach to generators procured by states (e.g., NJ)
- Sharing POIs is attractive: many aging resources are rarely dispatched when renewable generation is high

Examples:

- Separate MISO and SPP processes for existing POIs (unlike in PJM, presumes no material impact)
- MISO "energy displacement agreements" (between existing and new resources to ensure that the total amount of shared interconnection service at the POI remains the same)

Options for interconnecting resources more quickly and efficiently

2+3+4+5. Existing Headroom / First-ready / GETs & RAS / ERIS

- Identify "headroom" (hosting capacity, Order 2023 "heat map" requirement)
  - Example: CAISO identified interconnection requests for which 31 GW of energy-only headroom (23 GW of which are firmly deliverable) already exists without any additional network upgrades
- Fast-track generation resources that can be developed quickly (e.g., "first-ready" projects with minimal POI upgrades … beyond Order 2023 "first-ready, first-served" requirement)
  - Like PJM's "fast-lane" transition process for projects with minimal upgrades, but could be made permanent
  - CAISO's 2023 Interconnection Process Enhancements
- Allow interconnection needs to be addressed by grid-enhancing technologies (GETs) and "simple" remedial action schemes (RAS or system protection schemes, SPS)
  - GETs, such as power flow control devices, only need to be "considered" (but not used) per FERC Order 2023
  - RAS example: CAISO identified 21 GW of energy-only (16 GW of deliverable capacity) interconnection headroom that can be created quickly and inexpensively with RAS
- Simplify ERIS (energy-only) interconnection criteria for new POIs with option to upgrade to NRIS (capacity) later
  - Consider in interconnection studies the ability to manage (e.g., dispatch down) energy resources in nodal market
  - Examples: SPP ERIS, Enel working paper (speeds up energy-only interconnections to slim down the interconnection queue for firm (capacity) interconnections

Options for interconnecting resources more quickly and efficiently

6. Proactive, Holistic Long-term Transmission Planning

Proactively and holistically planning for long-term transmission needs can reduce total customer electricity costs and speed up interconnection of new resources

- Experience shows that simultaneously addressing all transmission needs (for generation interconnection, reliability, economic, public policy, and interregional needs) reduces costs:
  - CAISO TPP and European ENTSO-E planning and CBA framework, which includes interregional needs
  - MISO LRTP and Australian ISP (which do not consider interregional needs)
  - 2021 PJM study: $3.2b in transmission for 75 GW of clean energy resources -- shows that holistic planning for even just the next decade of generation interconnection needs would offer substantial cost reductions
- Concept: consider all near-term and long-term transmission needs (including public-policy needs through 2040-50) in approving the next decade of transmission upgrades
- Important: immediately reflect approved transmission upgrades in the “base case” for generation interconnection studies (e.g., as MISO did with approved MVPs)
- Include interregional solutions
  - Jointly plan for interconnection needs near seam (e.g., SPP-MISO JTIQ offering documented cost reductions)
  - Additionally: replace ineffective Coordinated Transaction Scheduling (CTS) with intertie optimization to improve utilization of interregional transmission and dispatch efficiency near seams, as recommended by IMM

Examples of Brattle Reports on Regional and Interregional Transmission Planning and Benefit-Cost Analyses

Well-Planned Electric Transmission Saves Customer Costs:
Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future

PREPARED FOR
WIRES

Link: Well-Planned Transmission

PREPARED BY
Judy W. Chang
Johannes P. Pfeifenberger

May 2016

THE Brattle GROUP

Toward More Effective Transmission Planning:
Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid

PREPARED FOR
WIRES

Link: Effective Transmission Planning

PREPARED BY
Johannes P. Pfeifenberger
Judy W. Chang
Akarsh Sheilendranath

April 2015

The Brattle Group

Link: Transmission Benefits

The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments

July 2013

Judy W. Chang
Johannes P. Pfeifenberger
J. Michael Hagerty

Link: Diversity Value

BU
Boston University Institute for Sustainable Energy

The Value of Diversifying Uncertain Renewable Generation through the Transmission System

September • 2020

A Roadmap to Improved Interregional Transmission Planning

Link: Interregional Roadmap

PREPARED BY
Johannes P. Pfeifenberger
Kasparas Spokas
J. Michael Hagerty
John Tsoukalis

November 30, 2021

Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs

Link: Brattle Grid Strategies

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OCTOBER 2021

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GRID STRATEGIES LLC

Summarizes proven approaches to quantifying various benefits

"Checklist" of Transmission Benefits With Proven Practices for Quantifying Them

We have documented in our recent report (filed with ANOPR comments), available proven practices:

1. Consider for each project (or synergistic portfolio of projects) the full set of benefits transmission can provide (*see* table)
2. Identify the benefits that plausibly exist and may be significant for that particular project or portfolio; then
3. Focus on quantifying those benefits

(See our recent report with Grid Strategies for a summary of quantification practices)

Benefit Category	Transmission Benefit
1. Traditional Production Cost Savings	Adjusted Production Cost (APC) savings as currently estimated in most planning processes
2. Additional Production Cost Savings	i. Impact of generation outages and A/S unit designations
	ii. Reduced transmission energy losses
	iii. Reduced congestion due to transmission outages
	iv. Reduced production cost during extreme events and system contingencies
	v. Mitigation of typical weather and load uncertainty, including the geographic diversification of uncertain renewable generation variability
	vi. Reduced cost due to imperfect foresight of real-time system conditions, including renewable forecasting errors and intra-hour variability
	vii. Reduced cost of cycling power plants
	viii. Reduced amounts and costs of operating reserves and other ancillary services
	ix. Mitigation of reliability-must-run (RMR) conditions
	x. More realistic "Day 1" market representation
3. Reliability and Resource Adequacy Benefits	i. Avoided/deferred cost of reliability projects (including aging infrastructure replacements) otherwise necessary
	ii. (a) Reduced loss of load probability or (b) reduced planning reserve margin
4. Generation Capacity Cost Savings	i. Capacity cost benefits from reduced peak energy losses
	ii. Deferred generation capacity investments
	iii. Access to lower-cost generation resources
5. Market Facilitation Benefits	i. Increased competition
	ii. Increased market liquidity
6. Environmental Benefits	i. Reduced expected cost of potential future emissions regulations
	ii. Improved utilization of transmission corridors
7. Public Policy Benefits	Reduced cost of meeting public policy goals
8. Other Project-Specific Benefits	Examples: increased storm hardening and wild-fire resilience, increased fuel diversity and system flexibility, reduced cost of future transmission needs, increased wheeling revenues, HVDC operational benefits

U.S. Reports on Competitive Transmission

Making the case <u>for</u> competition in electric transmission:

- 230609-caladvocates-increasing-competitive-solicitation-in-transmission.pdf
- Electricity Transmission Competition Coalition and CPUC Initial Comments on NOPR
- MA-AGO-NOPR-Reply-Comments
- R Street Reply Comments on FERC ANOPR
- Competition for Electric Transmission Projects (mit.edu)
- Cost Savings Offered by Competition in Electric Transmission: Experience to Date and Potential Value for Electricity Consumers - Brattle
- Report by Brattle Economists Discusses the Benefits of Competitive Transmission – Brattle
- Response to Concentric Energy Advisors’ Report on Competitive Transmission – Brattle
- How ROFR Laws Increase Electric Transmission Costs in Midwestern States - R Street Institute
- Counterflow: Say It Ain't So, Joe - RTO Insider

Making the case <u>against</u> competition in electric transmission:

- Building-New-Critical-Infrastructure.-No-Time-to-Waste.pdf (aii.org)
- WIRES Quarterly Newsletter April 2024
- An-Updated-Examination-of-FERC-Order-1000-Projects.pdf (ceadvisors.com)
- DATA supplemental NOPR comments
- Competitive Transmission: Experience To-Date Shows Order No. 1000 Solicitations Fail to Show Benefits (ceadvisors.com)

Brattle Group Publications on Transmission

DeLosa, Pfeifenberger, Joskow, Regulation of Access, Pricing, and Planning of High Voltage Transmission in the US, MIT-CEEPR working paper, March 7, 2024.
Pfeifenberger, How Resources Can Be Added More Quickly and Effectively to PJM's Grid, OPSI Annual Meeting, October 17, 2023.
Pfeifenberger, Bay, et al., The Need for Intertie Optimization: Reducing Customer Costs, Improving Grid Resilience, and Encourage Interregional Transmission, October 2023.
Pfeifenberger, Plet, et al., The Operational and Market Benefits of HVDC to System Operators, for GridLab, ACORE, Clean Grid Alliance, Grid United, Pattern Energy, and Allete, September 2023.
Pfeifenberger, DeLosa, et al., The Benefit and Urgency of Planned Offshore Transmission, for ACORE, ACP, CATF, GridLab, and NRDC, January 24, 2023.
Brattle and ICC Staff, Illinois Renewable Energy Access Plan: Enabling an Equitable, Reliable, and Affordable Transition to 100% Clean Electricity for Illinois, December 2022.
Pfeifenberger et al., New Jersey State Agreement Approach for Offshore Wind Transmission: Evaluation Report, October 26, 2022.
Pfeifenberger, DeLosa III, Transmission Planning for a Changing Generation Mix, OPSI 2022 Annual Meeting, October 18, 2022.
Pfeifenberger, Promoting Efficient Investment in Offshore Wind Transmission, DOE-BOEM Atlantic Offshore Wind Transmission Economics & Policy Workshop, August 16, 2022.
Pfeifenberger, Generation Interconnection and Transmission Planning, ESIG Joint Generation Interconnection Workshop, August 9, 2022.
Pfeifenberger and DeLosa, Proactive, Scenario-Based, Multi-Value Transmission Planning, Presented at PJM Long-Term Transmission Planning Workshop, June 7, 2022.
Pfeifenberger, Planning for Generation Interconnection, Presented at ESIG Special Topic Webinar: Interconnection Study Criteria, May 31, 2022.
RENEW Northeast, A Transmission Blueprint for New England, Prepared with Borea and The Brattle Group, May 25, 2022.
Pfeifenberger, New York State and Regional Transmission Planning for Offshore Wind Generation, NYSERDA Offshore Wind Webinar, March 30, 2022.
Pfeifenberger, The Benefits of Interregional Transmission: Grid Planning for the 21st Century, US DOE National Transmission Planning Study Webinar, March 15, 2022.
Pfeifenberger, 21st Century Transmission Planning: Benefits Quantification and Cost Allocation, for NARUC members of the Joint Federal-State Task Force on Electric Transmission, January 19, 2022.
Pfeifenberger, Spokas, Hagerty, Tsoukalis, A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.
Pfeifenberger, Tsoukalis, Newell, "The Benefit and Cost of Preserving the Option to Create a Meshed Offshore Grid for New York," Prepared for NYSERDA with Siemens and Hatch, November 9, 2022.
Pfeifenberger, Transmission–The Great Enabler: Recognizing Multiple Benefits in Transmission Planning, ESIG, October 28, 2021.
Pfeifenberger et al., Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, Brattle-Grid Strategies, October 2021.
Pfeifenberger et al., Initial Report on the New York Power Grid Study, prepared for NYPSC, January 19, 2021.
Van Horn, Pfeifenberger, Ruiz, "The Value of Diversifying Uncertain Renewable Generation through the Transmission System," BU-ISE, October 14, 2020.
Pfeifenberger, Newell, Graf and Spokas, "Offshore Wind Transmission: An Analysis of Options for New York", prepared for Anbaric, August 2020.
Pfeifenberger, Newell, and Graf, "Offshore Transmission in New England: The Benefits of a Better-Planned Grid," prepared for Anbaric, May 2020.
Tsuchida and Ruiz, "Innovation in Transmission Operation with Advanced Technologies," T&D World, December 19, 2019.
Pfeifenberger, "Cost Savings Offered by Competition in Electric Transmission," Power Markets Today Webinar, December 11, 2019.
Chang, Pfeifenberger, Sheilendranath, Hagerty, Levin, and Jiang, "Cost Savings Offered by Competition in Electric Transmission: Experience to Date and the Potential for Additional Customer Value," April 2019 and "Response to Concentric Energy Advisors' Report on Competitive Transmission," August 2019.
Ruiz, "Transmission Topology Optimization: Application in Operations, Markets, and Planning Decision Making," May 2019.
Chang, Pfeifenberger, "Well-Planned Electric Transmission Saves Customer Costs: Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future," WIRES&Brattle, June 2016.
Newell et al. "Benefit-Cost Analysis of Proposed New York AC Transmission Upgrades," on behalf of NYISO and DPS Staff, September 15, 2015.
Pfeifenberger, Chang, and Sheilendranath, "Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid," WIRES and Brattle, April 2015.
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Pfeifenberger, Hou, "Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada," on behalf of WIRES, May 2011.

Brattle Group Practices and Industries

ENERGY & UTILITIES

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

LITIGATION

- Accounting
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
- Product Liability
- Securities & Finance
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

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- Electric Power
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- Natural Gas & Petroleum
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