

# Ensuring Cost Effective Transmission to Support Affordable State Electricity Policies

PREPARED BY

Johannes Pfeifenberger

PRESENTED AT



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# The Challenge: How to Achieve an Affordable Energy Transition



## **The challenge to achieving an affordable energy transition is formidable:**

1. Much of the (aging) existing generating resources will need to be replaced over the next two decades
2. Electrification and data center load growth will double the amount of generation supply needed (even with EE)
3. Local, regional, and interregional transmission capacity will need to double or triple 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 delay policy goals
- High fixed costs will create uneconomic bypass of existing facilities, which will further increase total costs
- Unhappy customers and regulators create risk and challenges for regulated companies and their investors
- Utility credit ratings will deteriorate and limit the amount of investments that can be financed

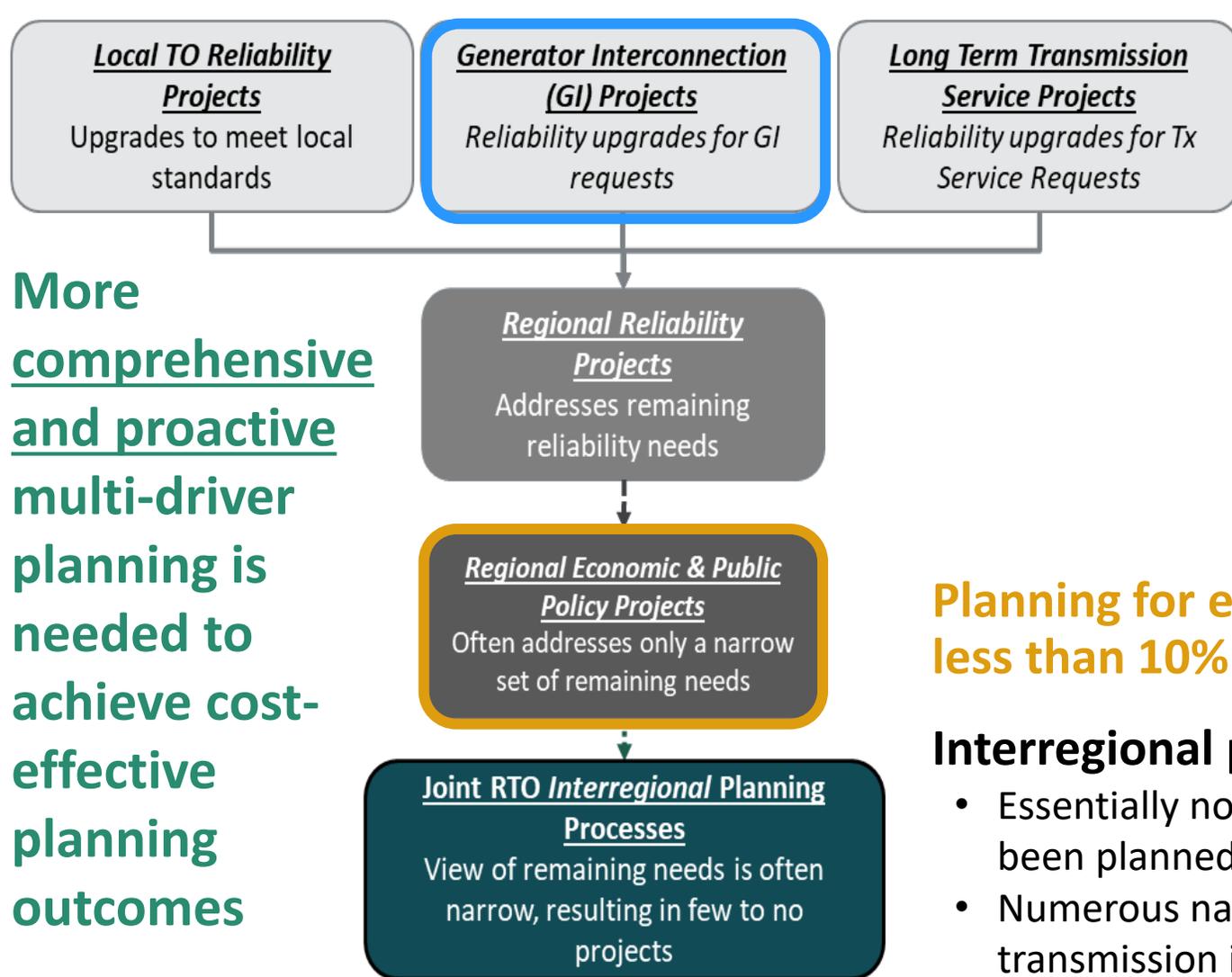
# Options for achieving a more affordable energy transition

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## 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

# More comprehensive, proactive planning is needed 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

# Order 1920 compliance offers opportunities to proactively plan a more cost-effective grid

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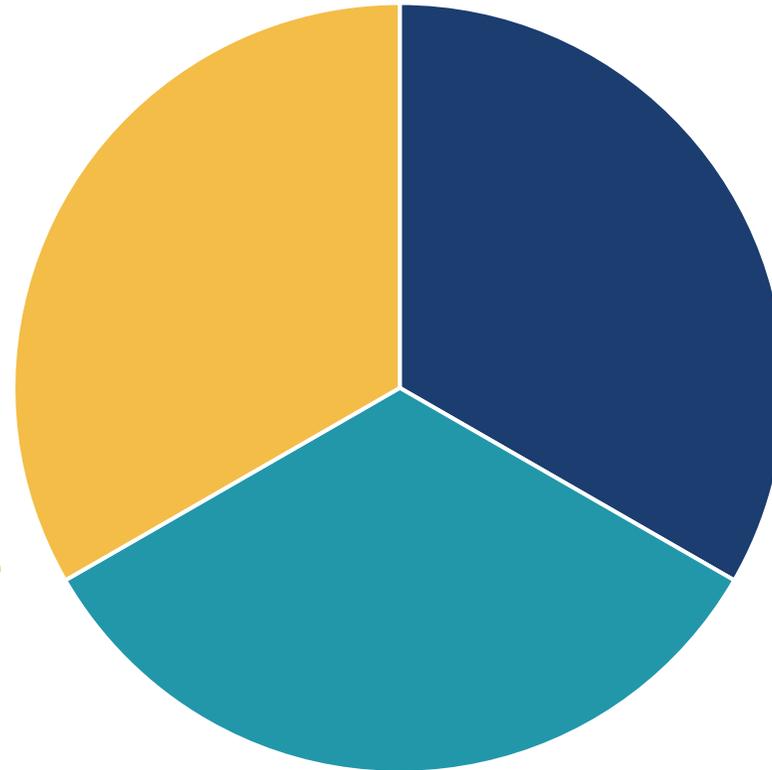
1. Better deal with long-term uncertainties through proactive scenario-based planning
2. Use best-practice experience for benefit quantification
3. Consolidate silo-ed planning processes
4. Employ least-regrets planning criteria to minimize the risk of both over-building and under-sizing
5. Develop more flexible transmission solutions
6. Embrace ATTs/GETs, focus on cost effectiveness, and include cost-control incentives
7. Explicitly consider interregional solutions to regional needs

See: [Order 1920 Compliance: An Opportunity to Improve Transmission Planning beyond Mandates](#)

# A “Loading Order” can expand transmission capacity more quickly and cost-effectively (with lower community impacts)

## 1. Advanced, grid enhancing technologies

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



## 2. Upgrades of existing lines

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

## 3. New transmission

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

### Examples:

[Priority order](#) required by the German “[NOVA Principle](#)”

MA [CETWG Report](#): Loading Order and ATT/GETs recommendations

# 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)
    - ▶ As often included in bids of competitive solicitations (see [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

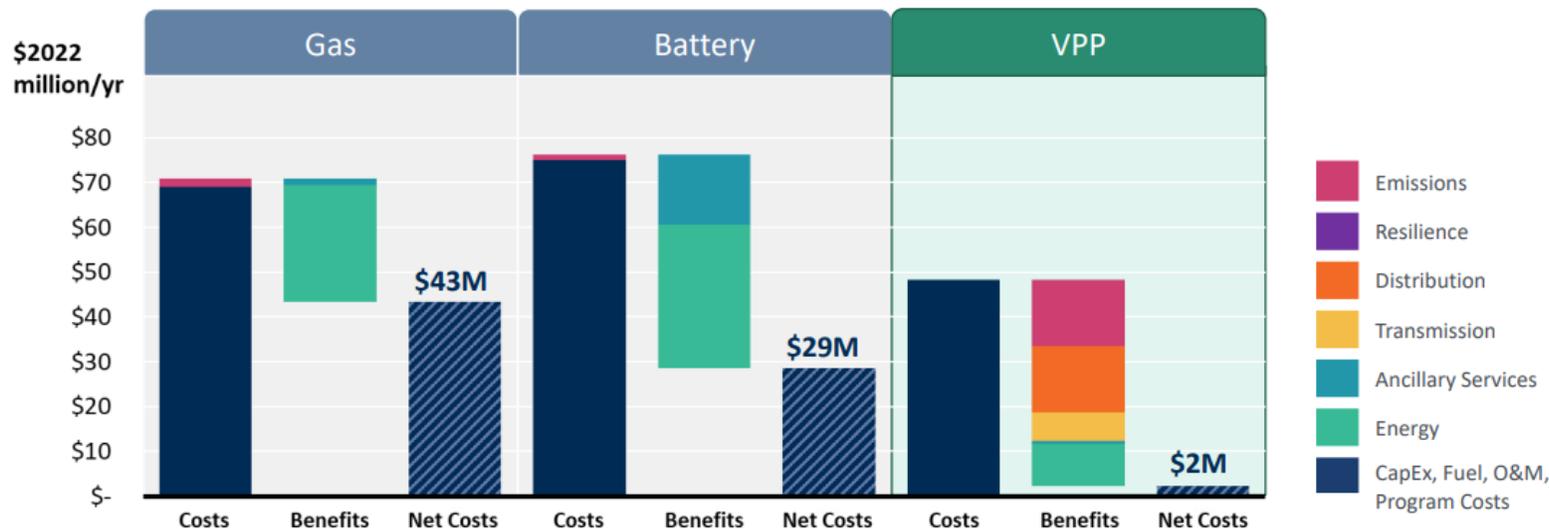
# And let's not forget ... ... efficiency and demand flexibility to reduce G+T+D costs

## **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**

Annualized Net Cost of Providing 400 MW of Resource Adequacy



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



# Thank You!

## Additional Slides

Note: an earlier version of these slides was presented on August 9, 2024 to the New England State Committee on Electricity (NESCOE): [Ensuring Cost-Effective Transmission in Support of a Clean Energy Transmission](#)

# About the Speakers

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**Johannes P. Pfeifenberger**

**PRINCIPAL  
THE BRATTLE GROUP, BOSTON**

[Hannes.pfeifenberger@brattle.com](mailto:Hannes.pfeifenberger@brattle.com)

+1.617.234.5624

[\(webbio and publications\)](#)

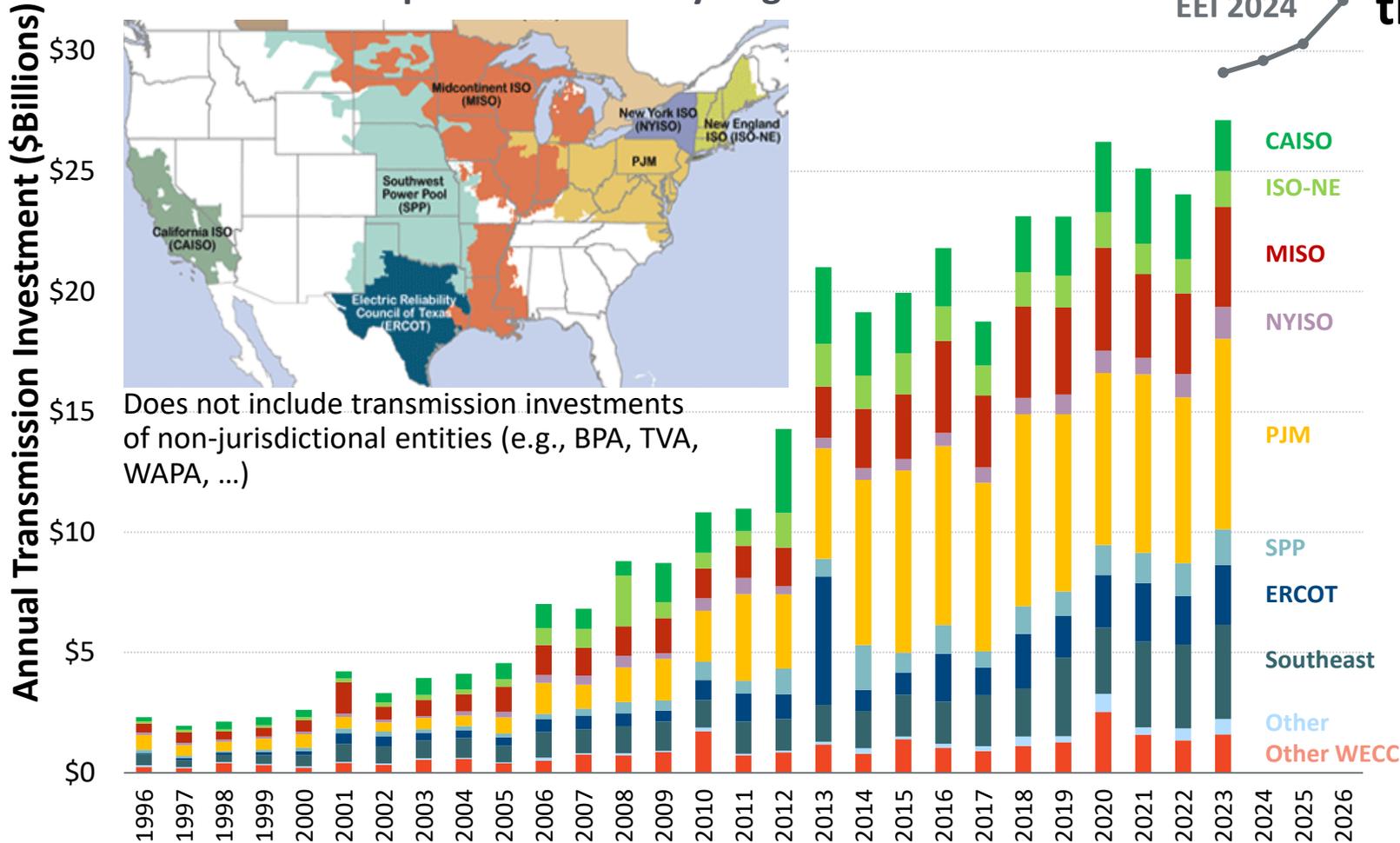
**Johannes (Hannes) Pfeifenberger**, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT’s 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

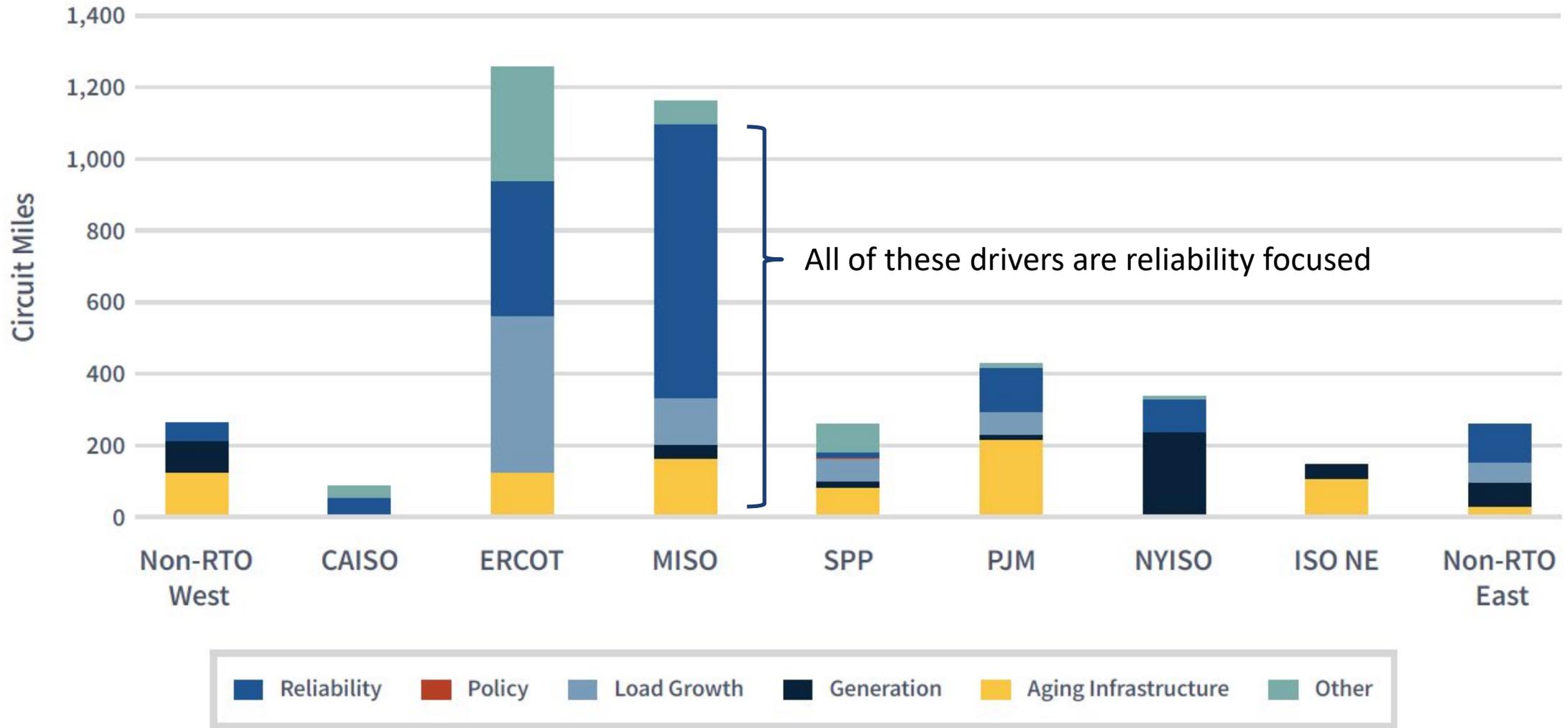
Annual Transmission Investment as Reported to FERC by Region



**\$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)

# The electricity industry is undergoing fundamental changes



As many have articulated, the industry faces a fundamental transition along three important dimensions (the “3Ds”):

## 1. DECARBONIZATION

Output from conventional resources is increasingly replaced by new generation technologies (including renewable resources and storage), with rapid technological improvements, close-to-zero variable costs, and ambitious state and corporate clean-energy goals. This is fundamentally changing (a) wholesale power prices; (b) grid operations; (c) electricity demand; and (d) grid planning and investments.

## 2. DECENTRALIZATION

Declining (relative) costs of solar generation and batteries also causes a shift away from large, central-station power plants to resources that are located on local electricity distribution grid or “behind the meter” at homes and businesses—changing the role (but not decreasing the value) of the bulk transmission grid.

## 3. DIGITALIZATION

The revolution in information and communication technologies and platforms that will continue to change nearly everything in our economy, including renewed electricity demand growth, energy services, grid operations, and grid planning.

# The main drivers of transmission needs

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**The structural changes in the electricity industry contribute significant transmission investment needs, driven mainly by:**

1. Renewed load growth
2. The need to refurbish aging transmission infrastructure
3. Generator interconnection needs, particularly for clean-energy resources
4. Poorly-timed and -planned retirements of aging generating plants
5. The economic and resilience benefits of broader regional and interregional diversification

**Investments necessary to upgrade the existing grid and build new transmission infrastructure will quickly exceed acceptable rate impact and available financing**

... unless mitigated through (a) targeted EE, DER, BESS; (b) GETs, advanced transmission technologies, more efficient grid operations; (c) upsizing existing lines and ROWs; and (d) proactive planning

# Substantial new load growth projected through 2030

Load growth from data centers, cypto mining, and industrial, transportation, and building electrification is projected to add more than 75 GW of load over the next 6 years.

- Transmission vs. T&D investments for load
- Added demand for clean-energy generation will require additional transmission



## DATA CENTERS

Data centers underpin the online economy technology sector and support the growth of artificial intelligence.

Current capacity: ~19 GW

Estimated electricity demand increase by 2030: **+16 GW**



## ONSHORING & INDUSTRIAL ELECTRIFICATION

Electrification of the industrial sector is a major pathway to reduce emissions. New sources of electric demand are triggered by the onshoring of manufacturing activity, hydrogen production (e.g., electrolyzers), indoor agriculture, and carbon dioxide removal.

Current capacity: ~116 GW

Estimated electricity demand increase by 2030: **+36 GW**



## CRYPTOCURRENCY MINING

Cryptocurrency mining is the process by which networks of computers generate and release new currencies and verify new transactions. Load from cryptocurrency mining is challenging to estimate because of its unique operational characteristics.

Current capacity: ~10–17 GW

Estimated electricity demand increase by 2030: **+8–15 GW**



## TRANSPORTATION ELECTRIFICATION

A growing number of customers purchase electric passenger vehicles as a more climate-friendly alternative to gas vehicles; medium- and heavy-duty vehicles, motorcycles, and ferries can all operate on electricity.

Current capacity: ~7 GW (electric vehicles)

Estimated electricity demand increase by 2030: **+8 GW**



## BUILDING ELECTRIFICATION

Electrification is a major pathway to decarbonize buildings and can include space heating (e.g., heat pumps), water heating (e.g., heat pump water heaters), and cooking (e.g., electric/induction cook stoves).

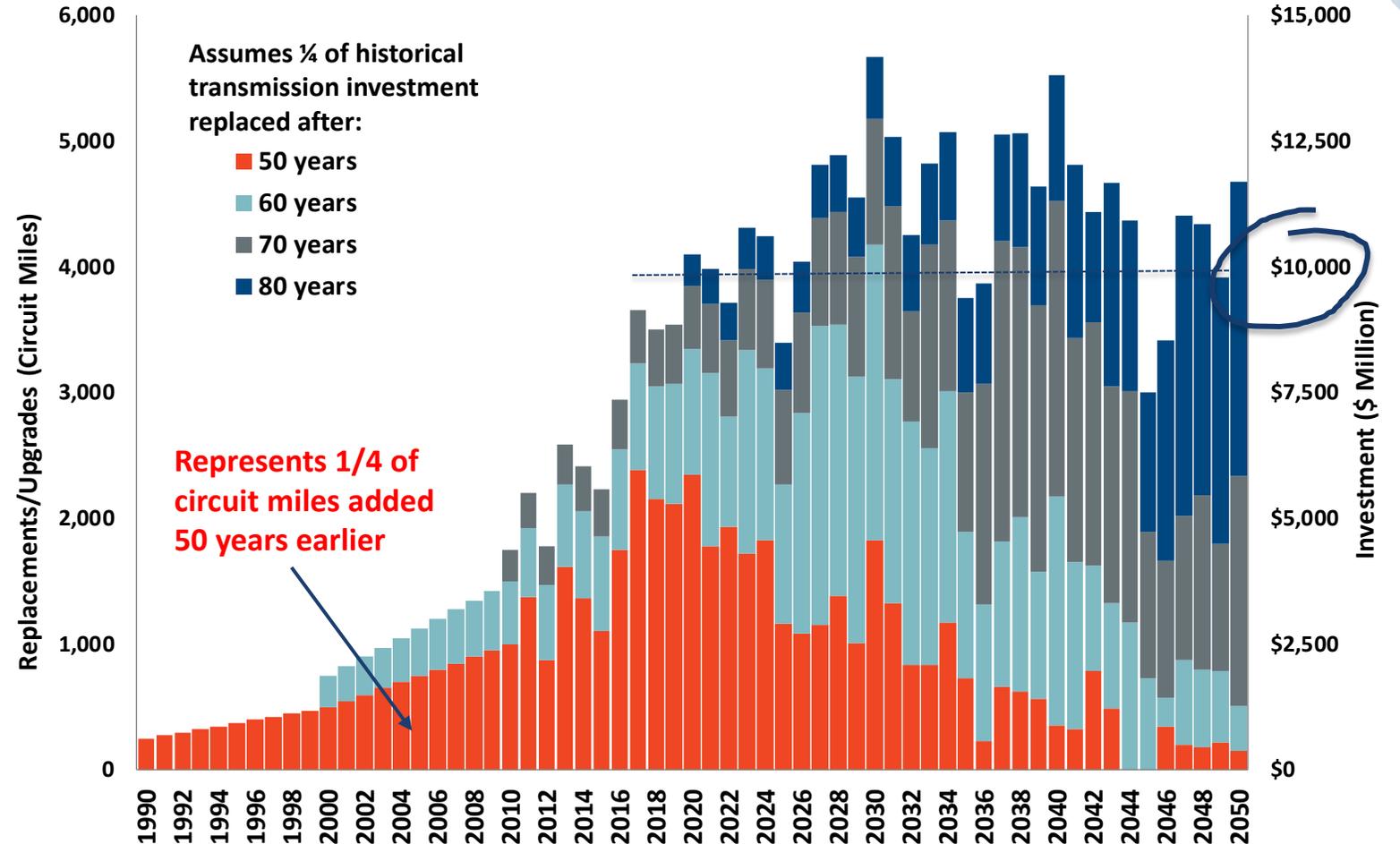
Current capacity: ~50 GW

Estimated electricity demand increase by 2030: **+7 GW**

# A large part of it: refurbishment of the aging US grid

- Much of today's grid was built in the 1960s and 70s
- Facilities that need to be replaced after 50 to 80 years, now likely account for \$10 billion in annual transmission investment
- Has reached 80% of total in some regions, such as PJM
- Some of these replacements are on highly-valuable right of way that could be used to “upsize” new facilities in cost-effective support of public policy goals

## Estimated U.S. Aging-Asset Refurbishment Need

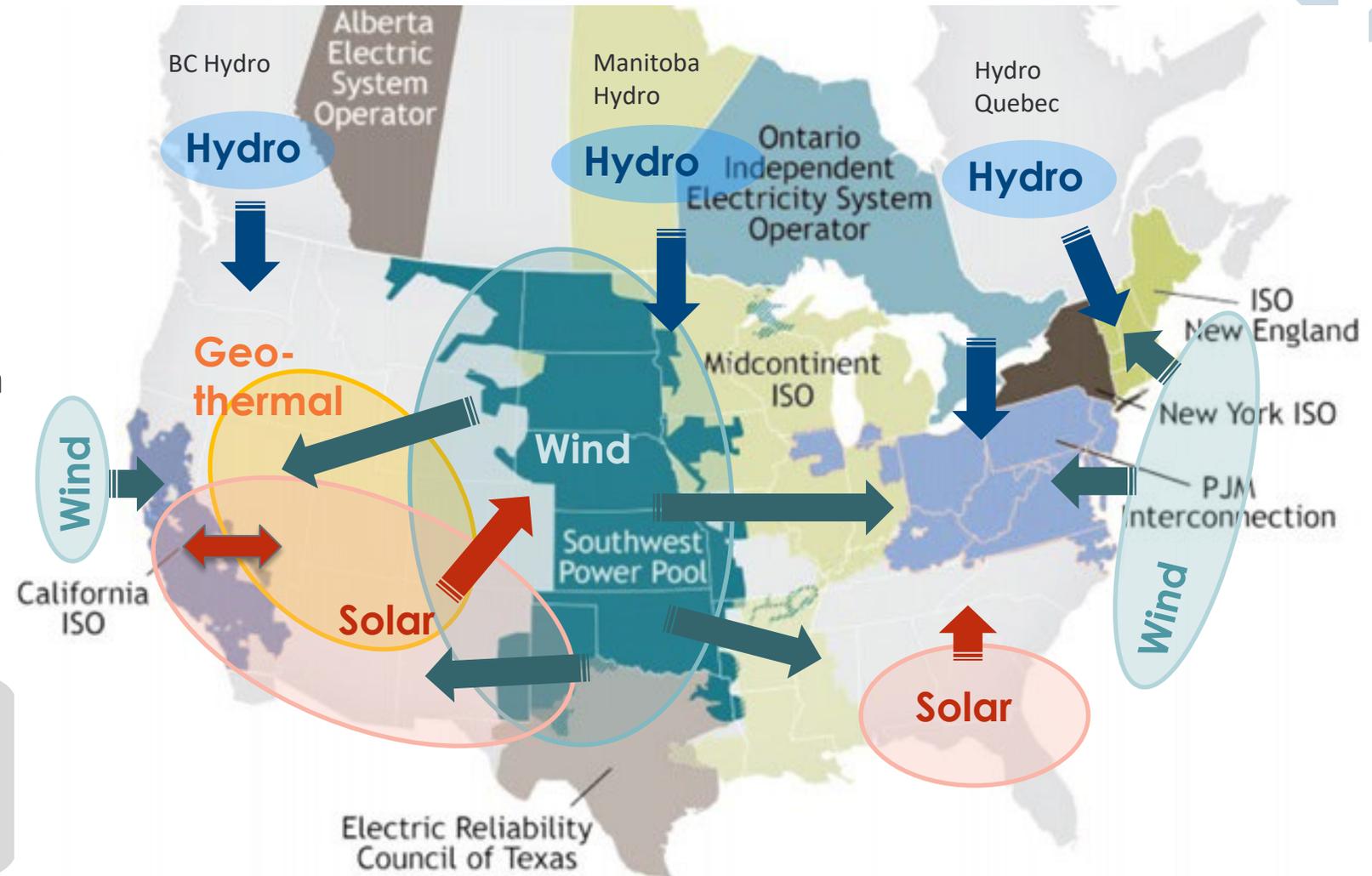


Source: Brattle estimate. Assumes \$2.5 million per refurbished circuit mile

# More interregional transmission will be beneficial to access and diversify low-cost renewable generation

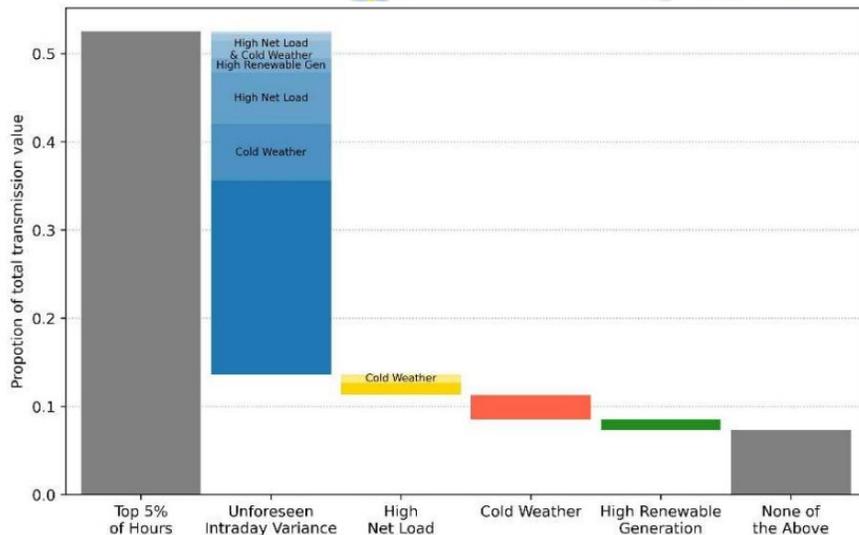
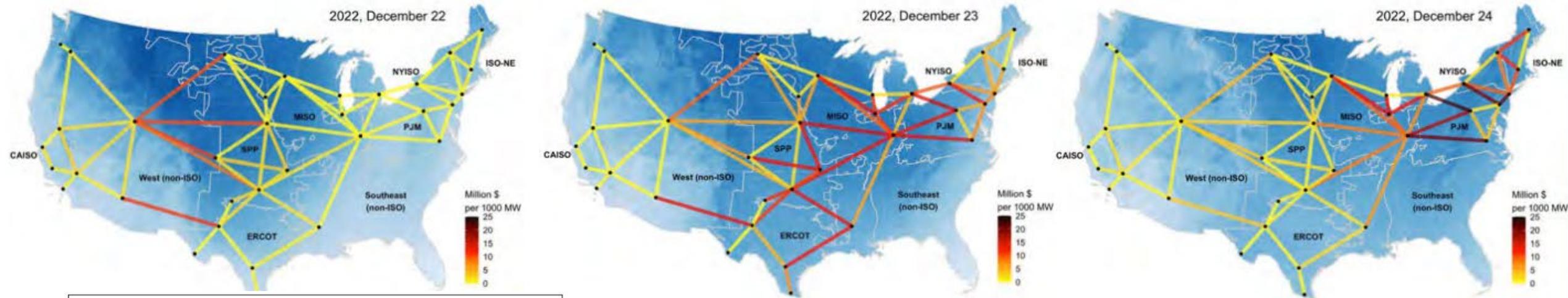
Beyond providing access to low-cost resources, grid-based resource diversification offers increasingly significant benefits:

- Regional diversification of resources and customers' electricity usage reduces the investment and balancing cost in a future with high levels of intermittent resources
- Diversity of resources and load increases the value of transmission between them
- The scale of robust grid solutions needs to exceed the size of large weather systems



# Transmission value is concentrated in only a few challenging hours

Highest transmission congestion is concentrated in relatively few hours of the year and during extreme events. Example: **Winterstorm Elliot (2022)**



## Findings:

- Real-time values (reflecting actual conditions) are higher than DA values
- On average, about **half of the value is concentrated in top 5% of all hours**
- Most of that value is due to unpredictable real-time market conditions that are not foreseeable on a day-ahead basis
- Estimated benefits exceed costs of expanding interregional paths

Sources: LBNL, [Transmission Value Manuscript NatureEnergy](#) (March 29, 2024);  
[Department of Energy's 2023 National Transmission Needs Study](#) (Oct 2023)

# More proactive planning will have to become business as usual

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## 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

# 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)

# Risk mitigation through better “Least-Regrets” planning

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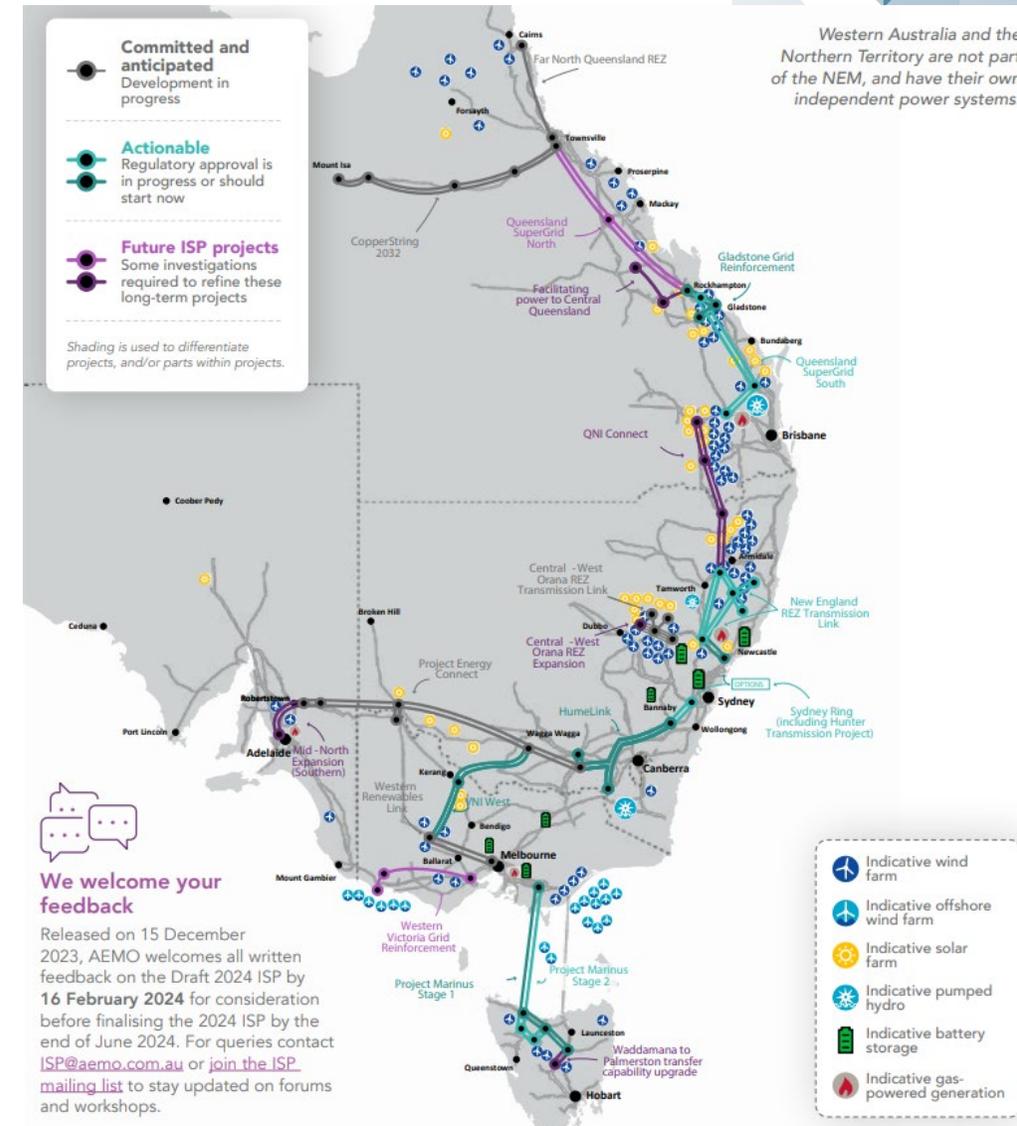
## Planning processes need to consider the risk-mitigation and insurance value of transmission infrastructure:

- 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 not only on (1) identifying projects that are beneficial under most cases; but also 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

# Example 1: Australian Integrated System Plan (ISP)

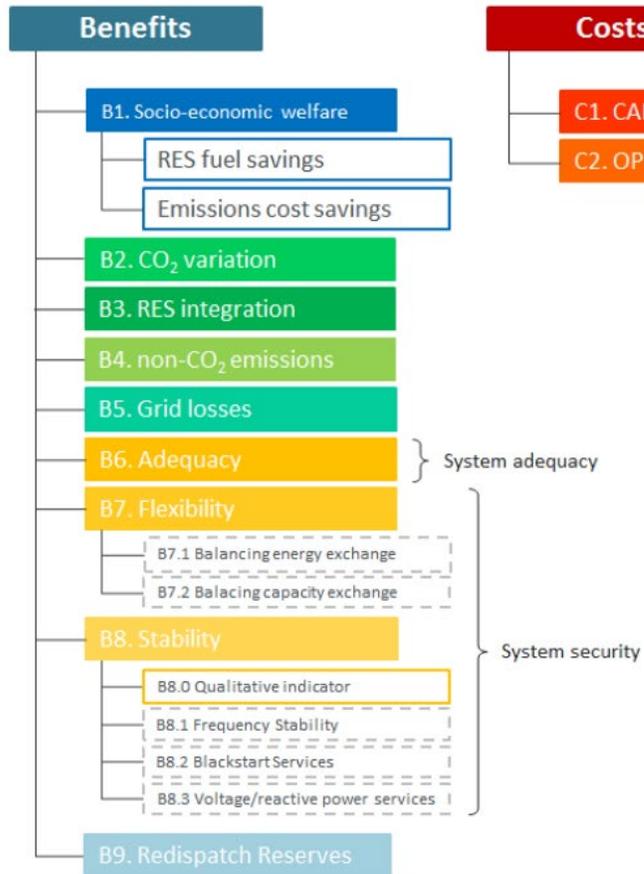
## The Australian Energy Market Operator (AEMO) integrated planning process is “best in class”:

- 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](#))



# Example 2: European 10-year Network Development Plans

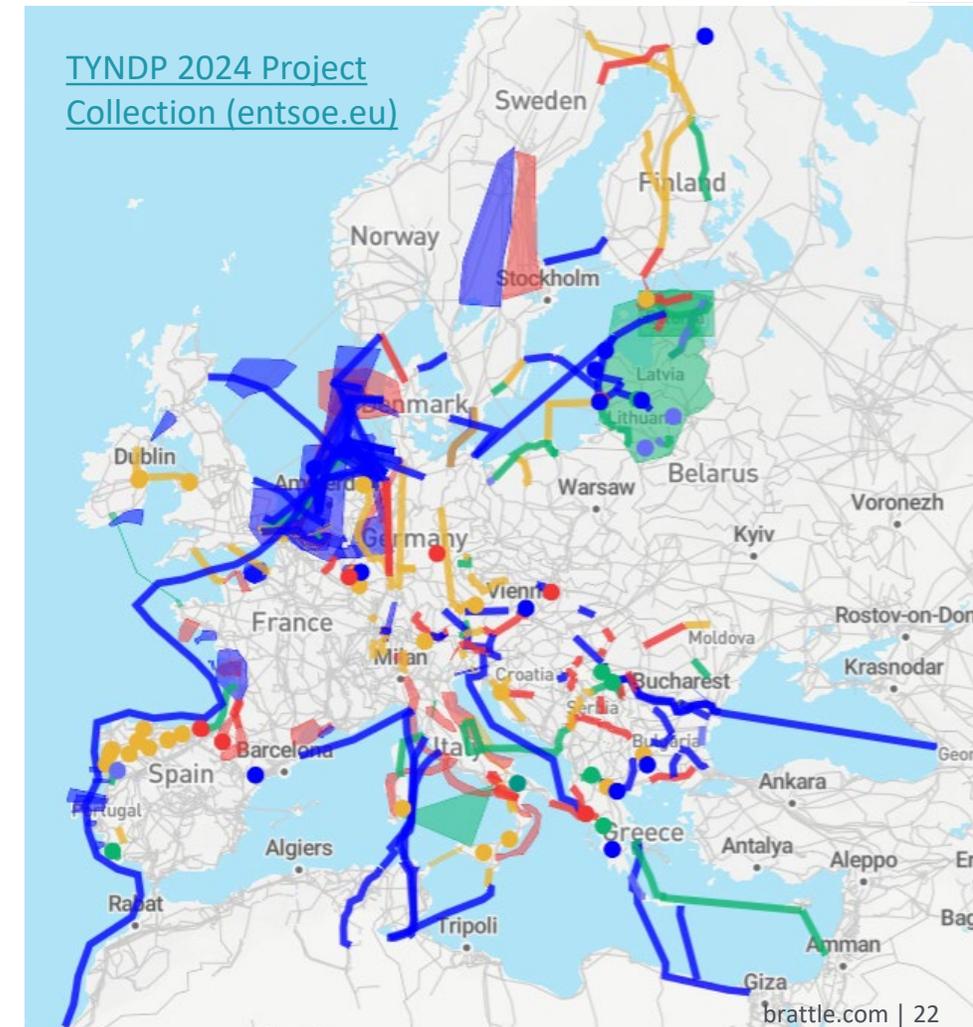
## ENTSO-E: Standardized Multi-value Benefit-Cost Analysis Framework for EU-wide Transmission Planning (incl. HVDC)



### 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

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



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](#).

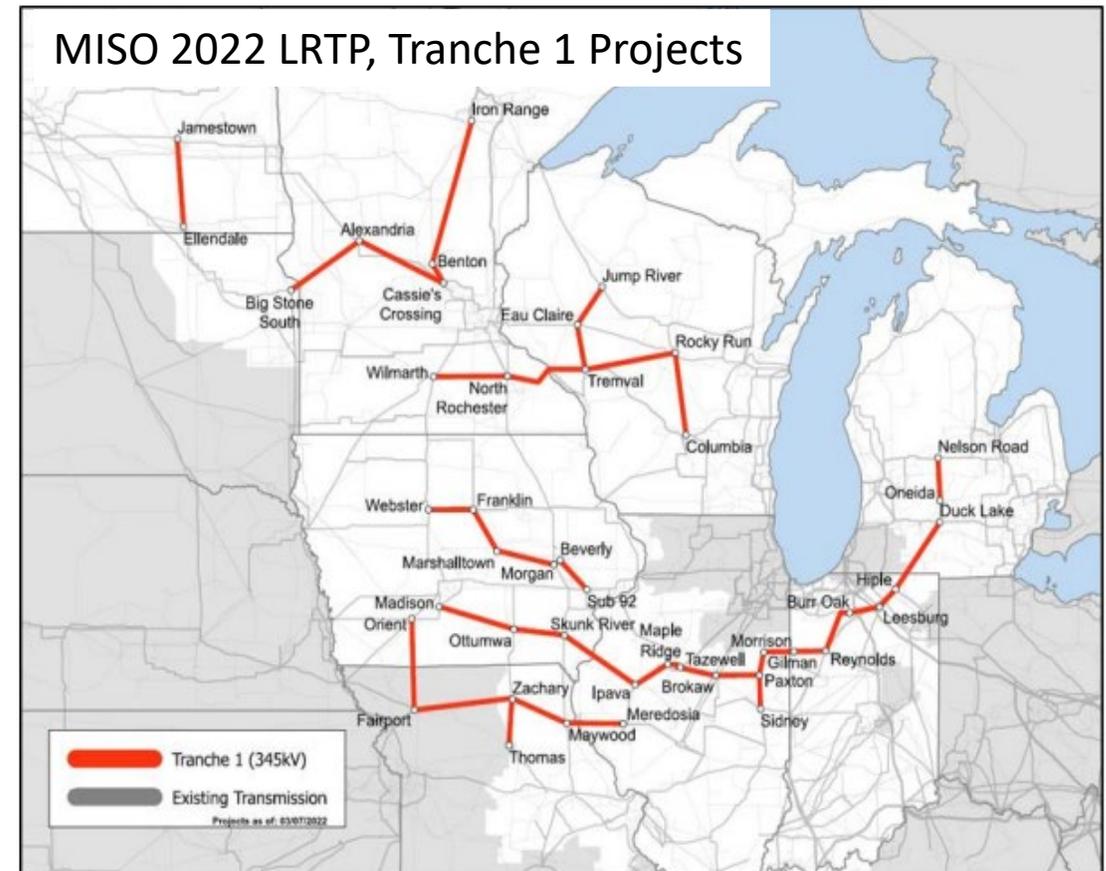
# Example 3: MISO Long-Term Transmission Planning (LRTP)

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

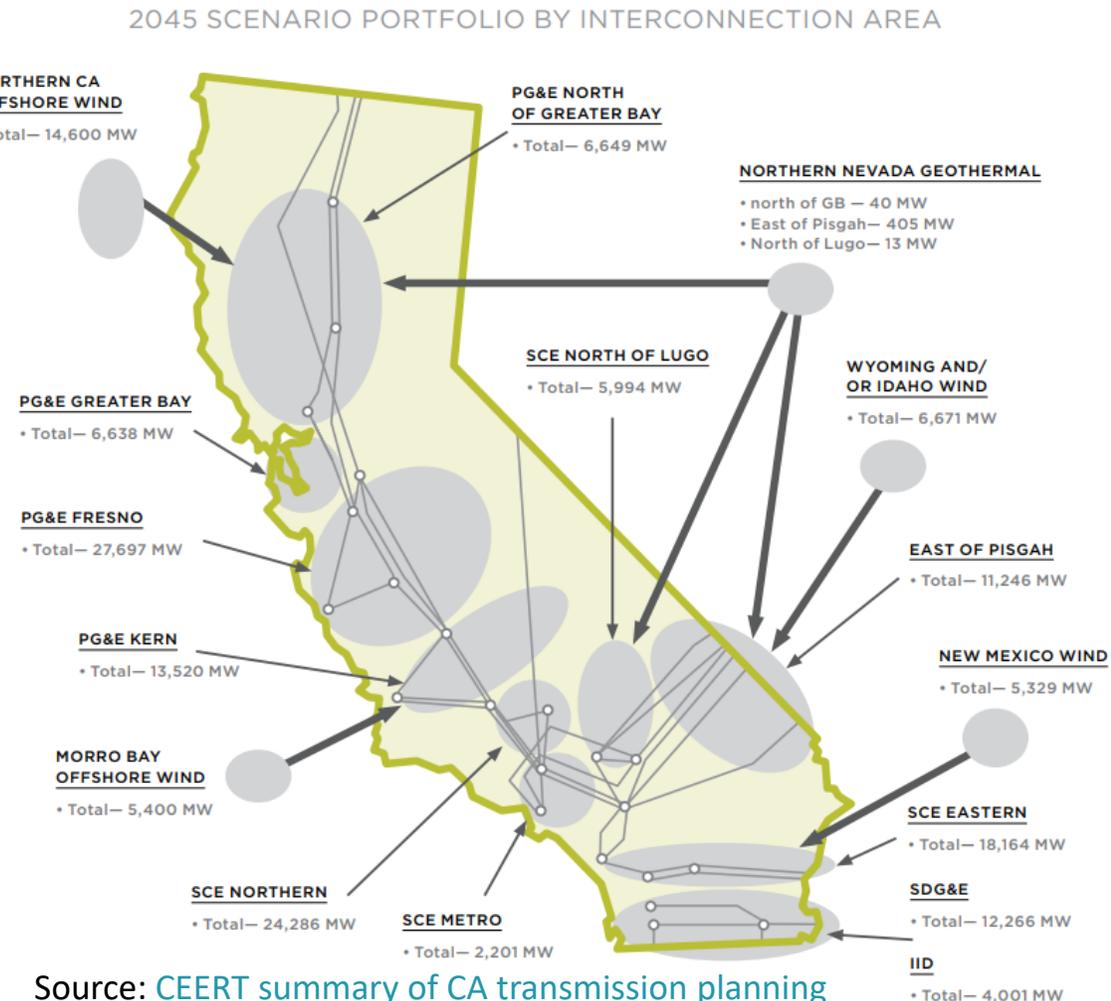
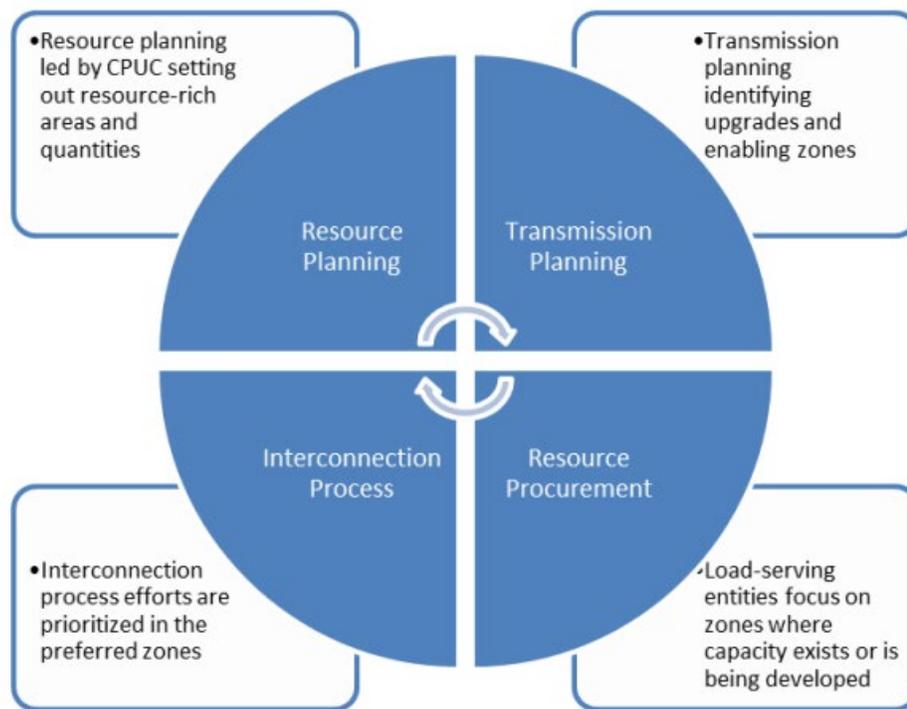
MISO is currently in the process of finalizing \$23 billion of Tranche 2 projects ([link](#))



# 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](#)



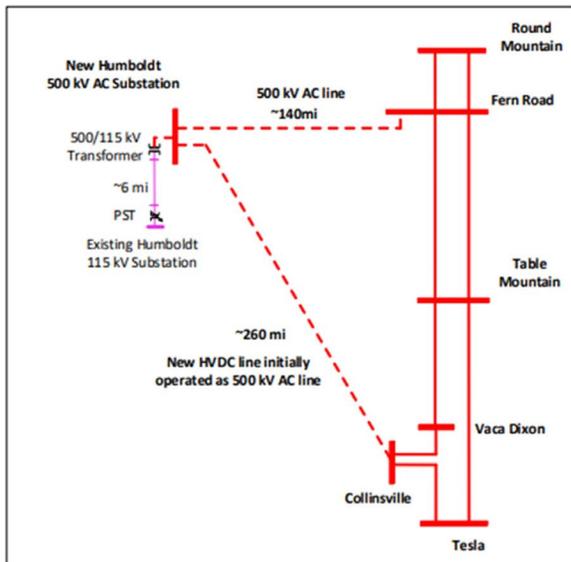
Source: [CEERT summary of CA transmission planning](#)

# 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.

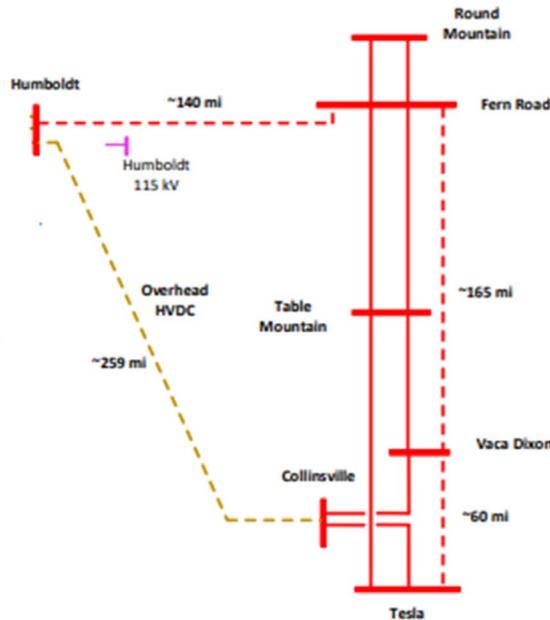
- Uses HVDC-ready 500 kV AC line with ROW for two HVDC lines

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



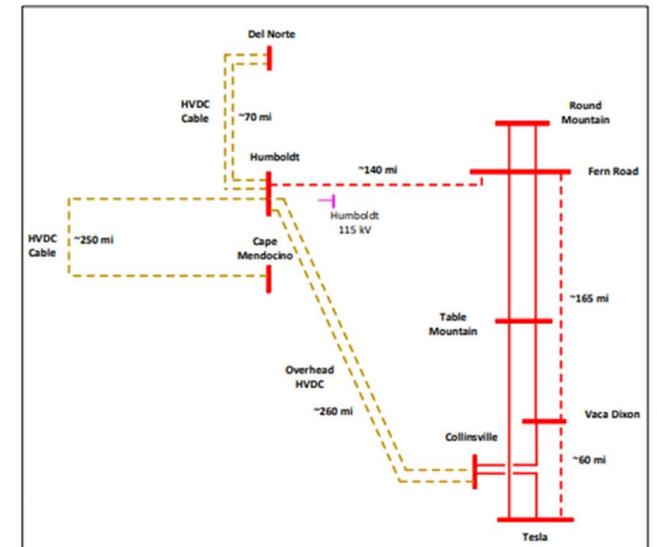
➔  
Add DC converter stations to each end of the line

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



➔  
Add a second HVDC line

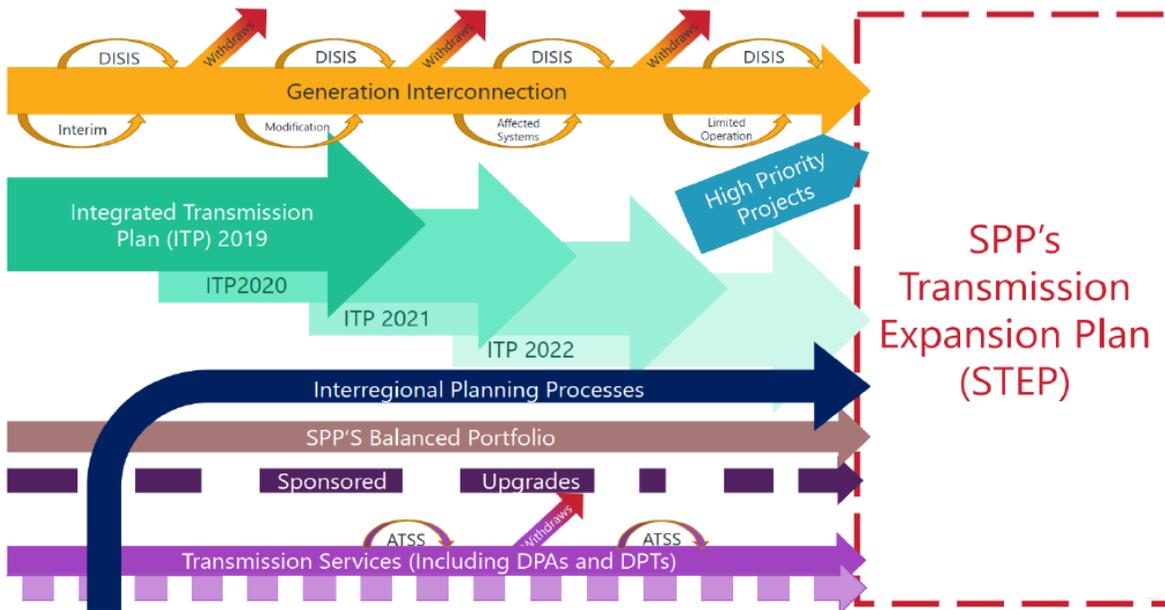
Phase 3: Expanded Plan (Option B)  
(8,045 MW)



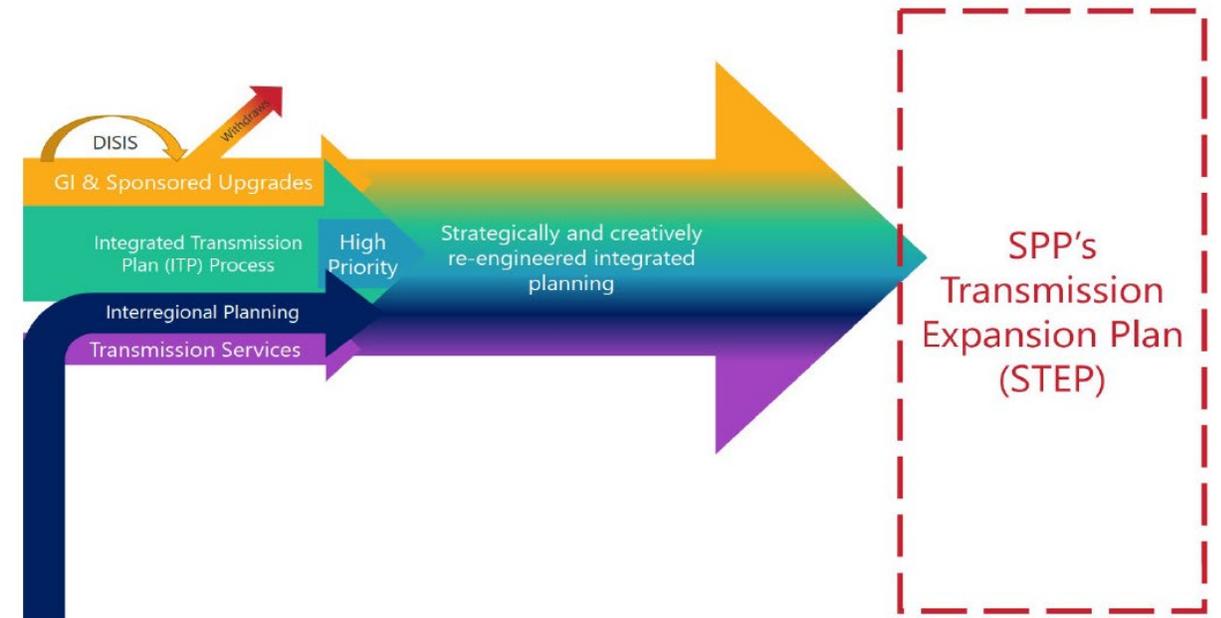
# Example 5: SPP's Proposed Consolidated Planning Process (CPP)

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



# Improving generator interconnection studies and planning

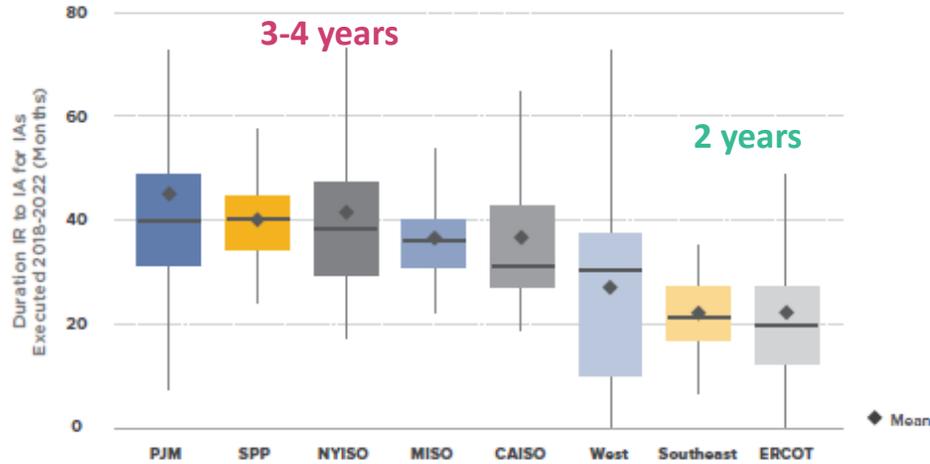


U.S. generator interconnection processes received [poor grades](#). Improving them requires addressing five elements of the interconnection processes:

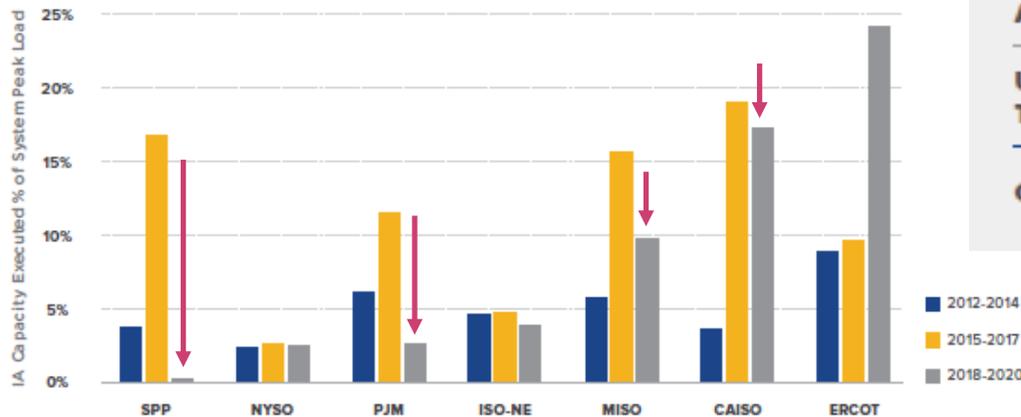
1. **GI [Process](#) and Queue Management:** individual vs. cluster studies, type of studies and contractual agreements, readiness criteria, financial deposits, study and restudy sequences, etc.
2. **GI [Scope](#) and “Handoff” to Regional Transmission Planning:** are major (“deep”) network upgrades 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

# Generator Interconnection: Scorecard assessing 2023 status quo

**FIGURE 5** | LBNL Estimate of Interconnection Process for IAs Executed from 2018 to 2022<sup>22</sup>



**FIGURE ES-1** | Interconnection Agreements Executed Through 2022 for Interconnection Requests Submitted from 2012-2020<sup>2</sup>



**TABLE 1** | Generator Interconnection Scorecard Grades

	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SPP
<b>Interconnection Process Results</b>	B-	A	C	C	D	D	C-
<b>Pre-queue Information</b>	C+	C	D	C+	C	C	C-
<b>Interconnection Study Process Design</b>	B	A-	C-	D+	B-	F	D
<b>Study Assumptions, Criteria, Replicability</b>	A	A+	C+	D	C+	F	C
<b>Usefulness of Interconnection Alternatives</b>	B+	B	D	B-	D	D	B
<b>Using Regional Transmission Planning</b>	A-	D	D	B	C+	D+	C+
<b>Overall grade</b>	B	B	D+	C-	C-	D-	C-

Source: GridStrategies-Brattle [Generator Interconnection Scorecard](#), Feb 2024.

# Generator interconnection: Recommended improvements

FERC sought to address the significant delays and backlogs associated with generator interconnection to the bulk transmission system in Order 2023:

- Adoption of cluster studies for interconnection requests in a given year
- Switch from “first-come, first-served” to “first-ready, first-served”
- Readiness requirements include higher study deposits, 90% site control at time of request, 100% at start of Facilities Study
- Publish heatmaps of available transmission capacity
- Deadlines for completion of interconnection studies
- Consideration of grid-enhancing technologies (GETs)

Order No. 2023 is a step in the right direction, but there is more to do to improve the interconnection process.

We (with GridStrategies) recommended these additional reforms that would increase the certainty and cost-effectiveness of generator interconnection

## GridStrategies-Brattle Report, [Unlocking America’s Energy: How to Efficiently Connect New Generation to the Grid](#) (August 2024)

- ▶ **REFORM 1** | *Adopt an interconnection entry fee for proactively planned capacity*, provides interconnection customers significant interconnection cost certainty and addresses cost allocation of the upgrades identified through proactive planning processes. This reform allows projects to move forward with upfront certainty by specifying in advance the cost information in exchange for taking on some of the cost of planned transmission buildout.
- ▶ **REFORM 2** | *Implement a fast-track process to utilize existing and already-planned interconnection capacity*, implements an efficient process to quickly utilize existing and planned system capacity. In combination with Reform 1, these reforms create a fast-track process that opens up available transmission headroom for full utilization and prioritizes its use by “most ready” generator projects.
- ▶ **REFORM 3** | *Optimize the interconnection study process*, targets improvements to the interconnection study process to increase the system headroom considered to be “available” for interconnecting new resources through existing and new fast-track processes. It also identifies reforms necessary to make the study process more efficient. In combination with Reforms 1 and 2, interconnection requests should proceed through the study process more quickly.
- ▶ **REFORM 4** | *Speed up the transmission construction backlog*, addresses growing constraints to constructing network upgrades needed to bring new resources online after completing the interconnection study process.

# 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)

Options for interconnecting resources more quickly and efficiently

## 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

# Well-documented: proven practices for quantifying a broad set of transmission benefits

## Take advantage of proven practices (as referenced in Order 1920)

- See our [report](#) with Grid Strategies for a summary of quantification practices, including benefits beyond the mandated ones

## Most recent developments:

- Use [weather-reflective](#) (rather than weather-normalized) production cost and long-term expansion planning simulations (e.g., for 20-30 weather years)
- Production cost simulations with both [day-ahead and real-time](#) cycles to capture unpredictable real-time challenges and associated transmission value

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

# 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  
 **Link: [Well-Planned Transmission](#)**

PREPARED BY  
Judy W. Chang  
Johannes P. Pfeifenberger

May 2014

THE **Brattle** GROUP

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

PREPARED FOR  
 **Link: [Effective Transmission Planning](#)**

PREPARED BY  
Johannes P. Pfeifenberger  
Judy W. Chang  
Akash Shellenbranath

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](#)**

 Boston University Institute for Sustainable Energy

The Value of Diversifying Uncertain Renewable Generation through the Transmission System

September • 2020



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

**Link: [Brattle Grid Strategies](#)**

PREPARED BY

*The Brattle Group:*  
Johannes Pfeifenberger  
Kasparas Spokas  
J. Michael Hagerty  
John Tsoukalis

*Grid Strategies:*  
Rob Gramlich  
Michael Goggin  
Jay Caspary  
Jesse Schneider

OCTOBER 2021



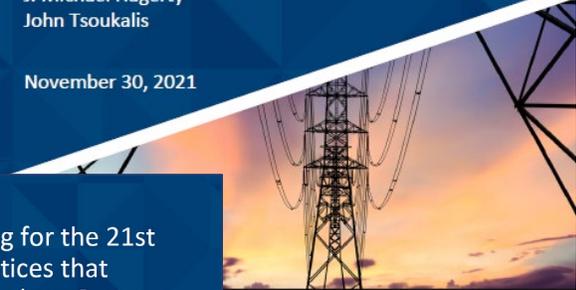
**Brattle** **GRID STRATEGIES LLC**

**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



Summarizes proven approaches to quantifying various benefits

# 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

# 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)



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

# U.S. Reports on Competitive Transmission

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## Making the case for 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](#)
- [R Street Responds: Aii Report Does Not Rebuke the Merits of Electric Transmission Competition - R Street Institute](#)

## Making the case against 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 \(ceadvisors.com\)](#)

# Significant barriers to planning new interregional transmission

## A. Leadership, Alignment and Understanding

1. Insufficient leadership from RTOs and federal & state policy makers to prioritize creating effective interregional planning processes
2. Limited trust amongst states, RTOs, utilities, & customers
3. Limited understanding of transmission issues, benefits & proposed solutions
4. Misaligned interests of RTOs, TOs, generators & policymakers
5. States prioritize local interests, such as development of in-state renewables

## B. Planning Process and Analytics

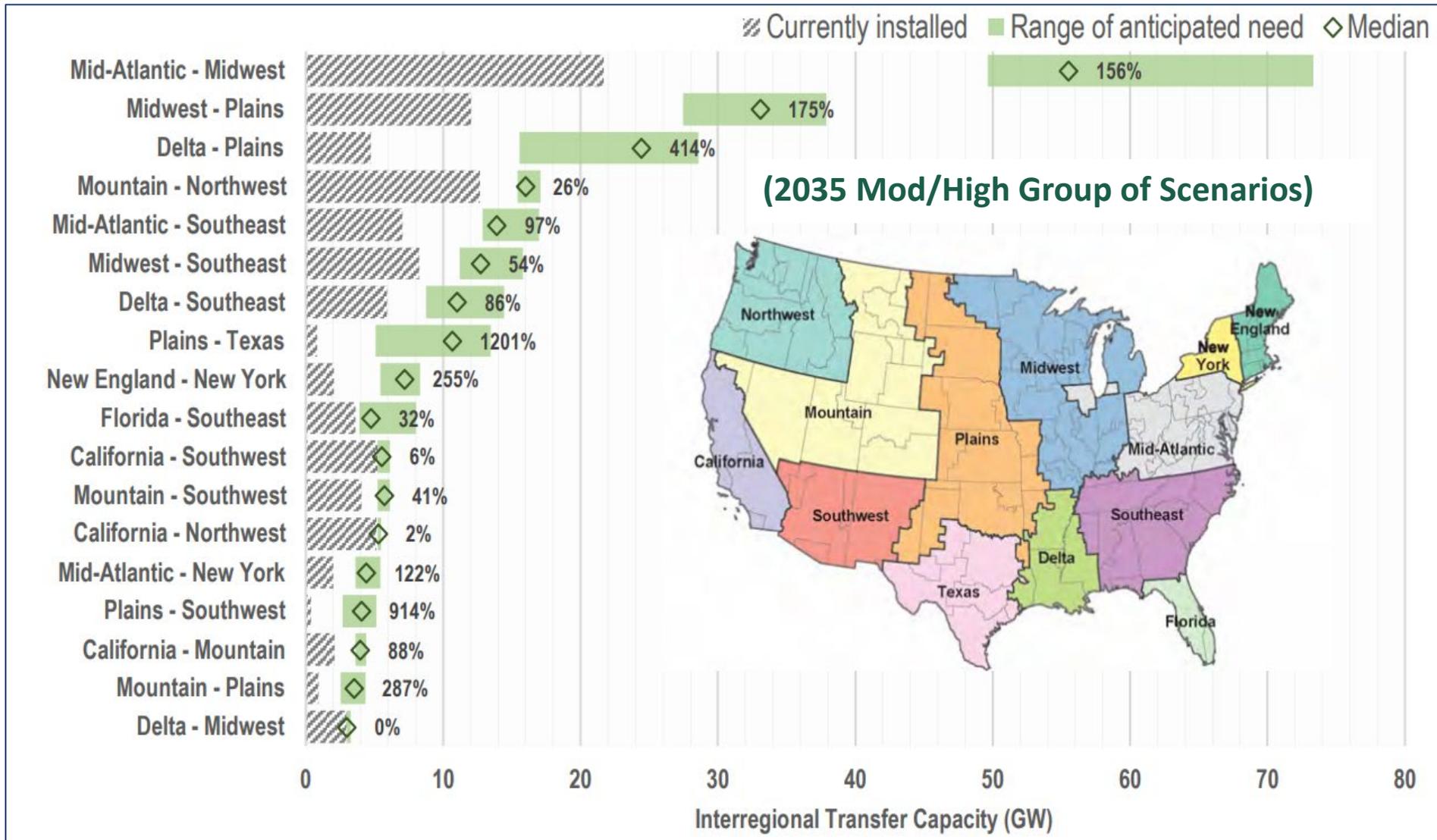
6. Benefit analyses are too narrow, and often not consistent between regions
7. Lack of proactive planning for a full range of future scenarios
8. Sequencing of local, regional, and interregional planning
9. Cost allocation (too contentious or overly formulaic)

## C. Regulatory Constraints

10. Overly-prescriptive tariffs and joint operating agreements
11. State need certification, permitting, and siting

Source: Appendix A of [A Roadmap to Improved Interregional Transmission Planning](#), November 30, 2021. Based on interviews with 18 organizations representing state and federal policy makers, state and federal regulators, transmission planners, transmission developers, industry groups, environmental groups, and large customers.

# DOE's 2023 Transmission Needs Study: 2035 Interregional Needs



**Source:** DOE, [National Transmission Needs Study](#), October 2023 (report) and [Department of Energy's 2023 National Transmission Needs Study](#) (slides)

**Note:** Expansion options include enhancing the existing grid & existing ROW plus new transmission lines

# DOE's 2024 NTPS confirms significant future transmission needs

## DOE recently-completed National Transmission Planning Study ([NTPS](#)) finds that:

1. The lowest-cost U.S. electricity system that can **reliably meet future demand** includes substantial **local, regional, and interregional** transmission expansion
  - To achieve the most cost-effective outcomes, the nation's **transmission capacity would have to expand 50-100% by 2035** and **2.4-4.1 times by 2050** at a cost of \$760 billion to \$1.4 trillion
  - If well-planned, approximately **\$1.60 to \$1.80 is saved for every dollar spent** on transmission
2. Multi-state and interregional coordination, using both existing and new local, regional, and interregional transmission, can **save \$270 billion to \$1 trillion through 2050**
  - The largest savings come from (1) coordinating resource adequacy and (2) expanding interregional transmission to exceed 30% of most regions' peak load
3. To achieve these outcomes, the **consolidation of siloed planning processes** is critical
  - Planning needs to consider extreme events, technology advancements, and demand uncertainty
  - Better interregional coordination is needed to efficiently utilize interregional transmission

# Limitations of National Studies



Although existing many studies demonstrate the benefits of transmission expansion, they have not been successful motivating actual transmission project developments. The reasons include some or all of the following:

- Many studies **tend to analyze aspirational clean energy targets (e.g., 90% by 2035 or 100% by 2050)** not the actual policies and mandates applicable for the next 10-15 years
  - By not modeling actual state or federal policies, clean-energy mandates, and renewable technology preferences, the studies cannot demonstrate a compelling “need” to policy makers, regulators, and permitting agencies
- The studies are **not transmission planning studies**: they often do not identify specific transmission projects nor do they support an actionable need such projects
  - The results of these studies do not connect with RTO planning processes and needs identification
- Studies **do not to identify how benefits and costs are distributed** across utility service areas, states, or RTO/ISO under different scenarios, as would be necessary to gain support and develop feasible cost allocations
  - The studies typically do not consider or propose how to recover (“allocate”) transmission costs
- There has not been **an analysis of the state-by-state economic impact and job creation** from interregional transmission development, reduced electricity prices, and shifts in the locations of clean-energy investment
- Most studies do not address the many barriers to planning processes and to the permitting/development of specific interregional transmission projects

# Order 1920 may facilitate planning of interregional transmission

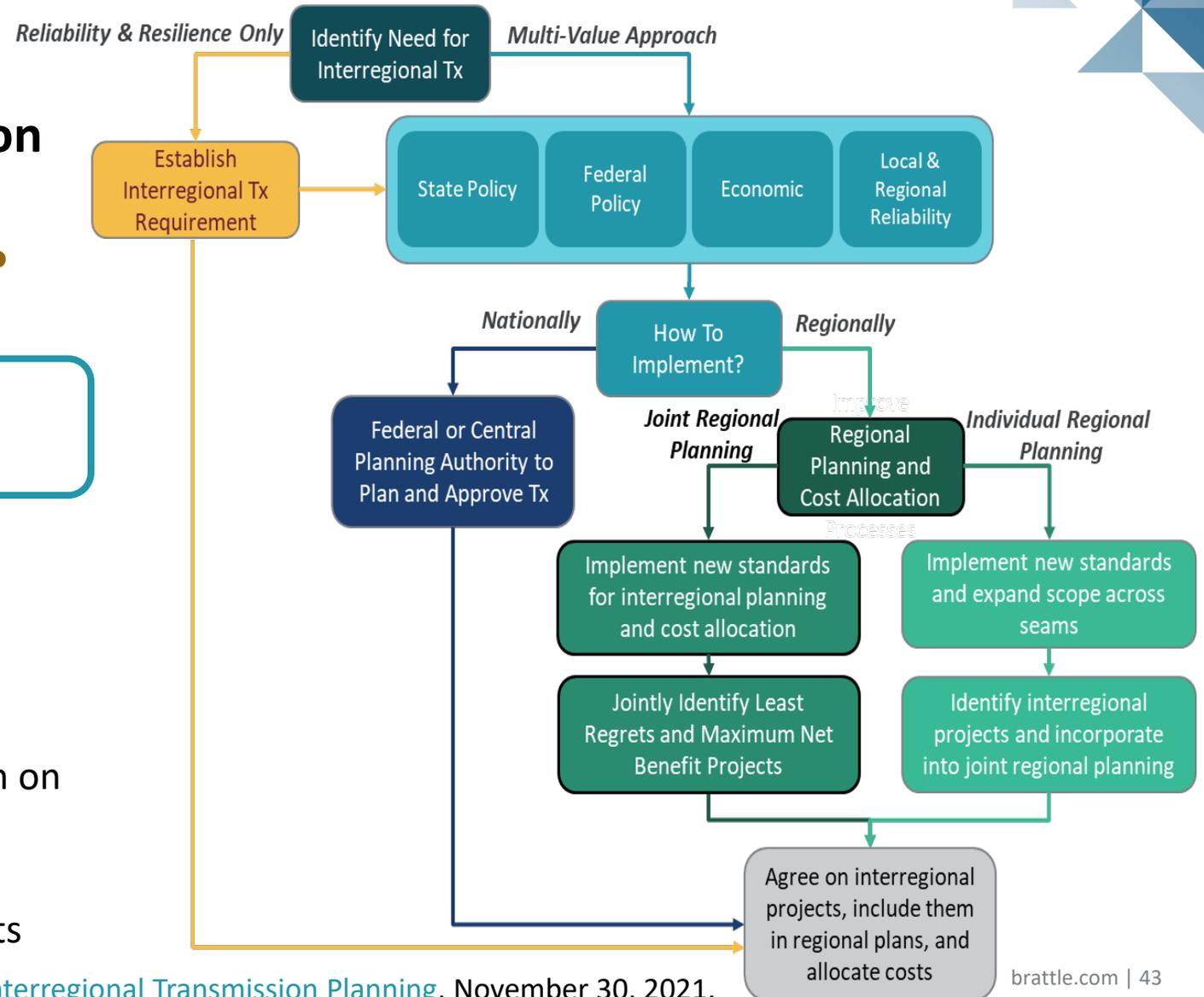
Four pathways are available for actionable interregional transmission planning:

1. New Interregional Tx requirements?
2. New Federal planning?
3. Improve joint RTO planning
4. Expand planning by individual RTOs

These could be improved through Order 1920 compliance

Order 1920 only requires improved interregional coordination:

- Sharing new long-term planning information on needs and possible solutions
- Process for proposing interregional projects
- Regional evaluations of interregional projects



# Brattle Group Publications on Transmission

Gramlich, Hagerty, et al., [Unlocking America's Energy: How to Efficiently Connect New Generation to the Grid](#), Grid Strategy and Brattle, August 2024.

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.

Chang, Pfeifenberger, Hagerty, ["The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments,"](#) on behalf of WIRES, July 2013.

Chang, Pfeifenberger, Newell, Tsuchida, Hagerty, ["Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process,"](#) October 2013.

Pfeifenberger and Hou, ["Seams Cost Allocation: A Flexible Framework to Support Interregional Transmission Planning,"](#) on behalf of SPP, April 2012.

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

## INDUSTRIES

Electric Power  
Financial Institutions  
Infrastructure  
Natural Gas & Petroleum  
Pharmaceuticals  
& Medical Devices  
Telecommunications,  
Internet, and Media  
Transportation  
Water

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