National Transmission Planning Study

March 15, 2022

1:00 PM - 3:00 PM ET

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Jennifer M. Granholm

Secretary of Energy

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Patricia Hoffman

Acting Director,

Grid Deployment Office

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Agenda

- **Welcome and housekeeping**
- **Introductory remarks**
  - Jennifer Granholm, United States Secretary of Energy
  - Pat Hoffman, Office of Electricity at the U.S. Department of Energy
- **Plenary panel**
  - Brett Carter, Xcel Energy
  - Debbie Lew, Energy Systems Integration Group (ESIG)
  - Lauren Azar, Azar Law LLC
  - Johannes Pfeifenberger, Brattle
  - Q&A
- **Study overview**
  - Objectives
  - Modeling
  - Public engagement
  - Q&A
- **Next steps**

Welcome and Housekeeping

- **Thank you** for joining and for participating!
- Webinar is being recorded and slides will be made available on the National Transmission Planning (NTP) Study website
- All participants are in listen-only mode
- We welcome your comments and questions
  - Questions for speakers and panelists can be entered into the Q&A box
  - Where applicable in your questions, please reference the speaker or topic
- It is not the object of this session to obtain any group position or consensus

Plenary Panel

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Brett Carter

Xcel Energy

Debbie Lew

Energy Systems Integration Group (ESIG)

Lauren Azar

Azar Law LLC

Johannes Pfeifenberger

Brattle

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Brett Carter

Executive Vice President and Chief
Customer and Innovation Officer

Xcel Energy

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Unlock the value for customers

Brett C. Carter I EVP, Group President Utilities, and Chief Customer Officer

March 15, 2022

Our customer expectations

Residential

Reliable Energy

Affordability and Support

Comfort and Easy

Choice and Control

Sustainability

Responsive

Small Business

Reliable Energy

Affordability and Support

Choice and Control

Comfort and Easy

Sustainability

Business Support Partner

C&I

Cost Reduction

Improve Sustainability

Excellent Power Quality

Resiliency

Simplify Operation

Collaborative Partner

Empower customers to take carbon off the grid

Principles

Keep **customers** (all classes of customers) at the center of the work

Address congestion to unlock full value

Identify and focus on opportunities for **unique impact** of federal investment


Xcel Energy®

Debbie Lew

Associate Director

Energy Systems Integration Group (ESIG)

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

The need for national transmission planning

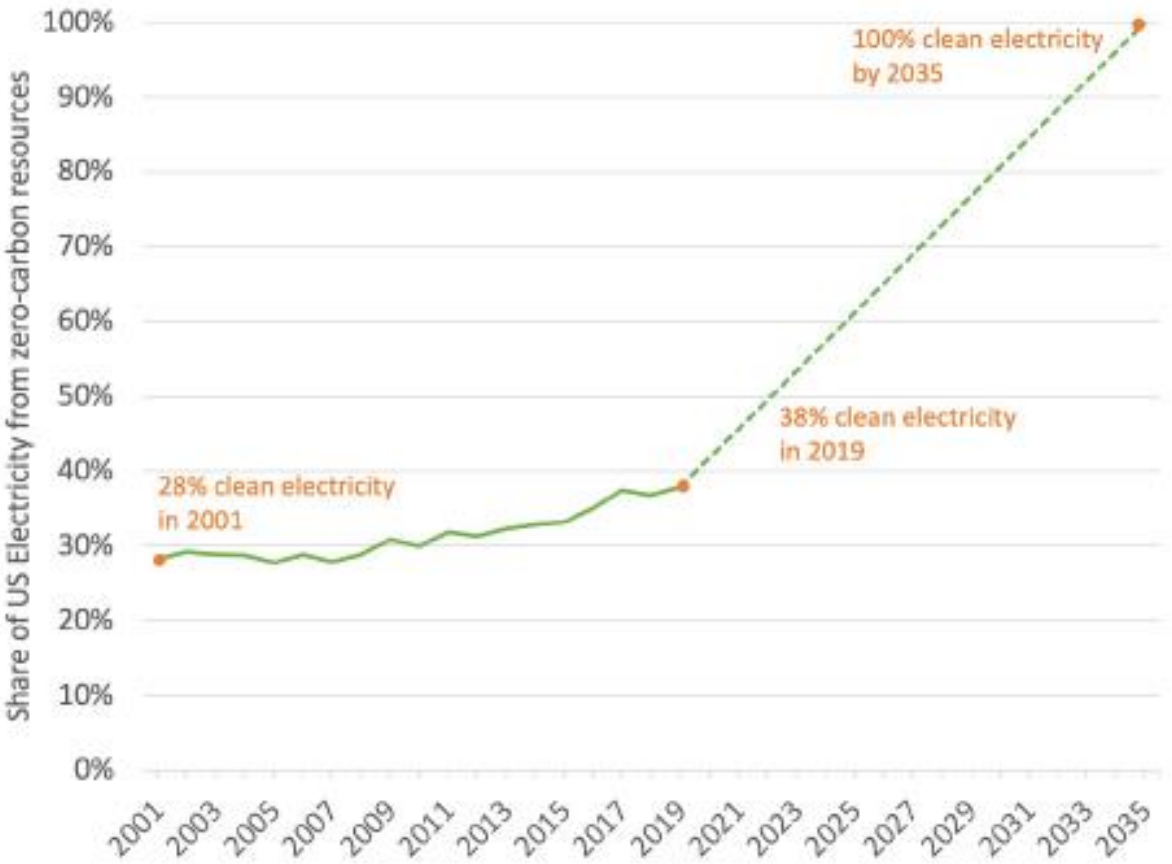
ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Debra Lew

DOE National Transmission Planning Study webinar

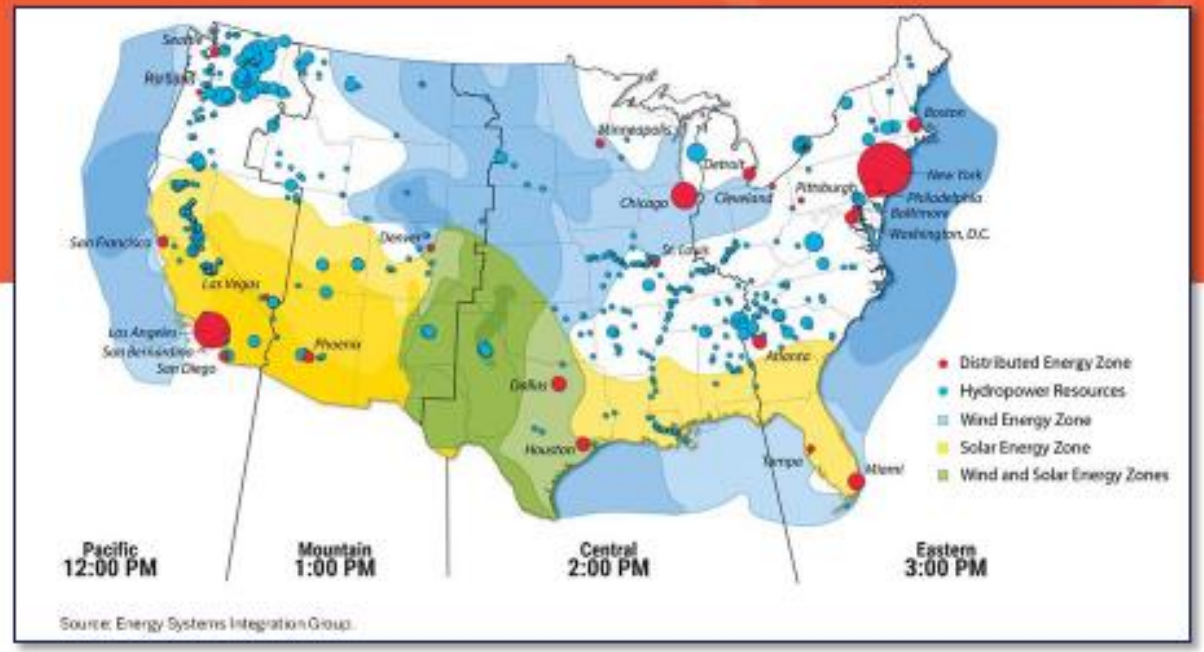
March 15, 2022

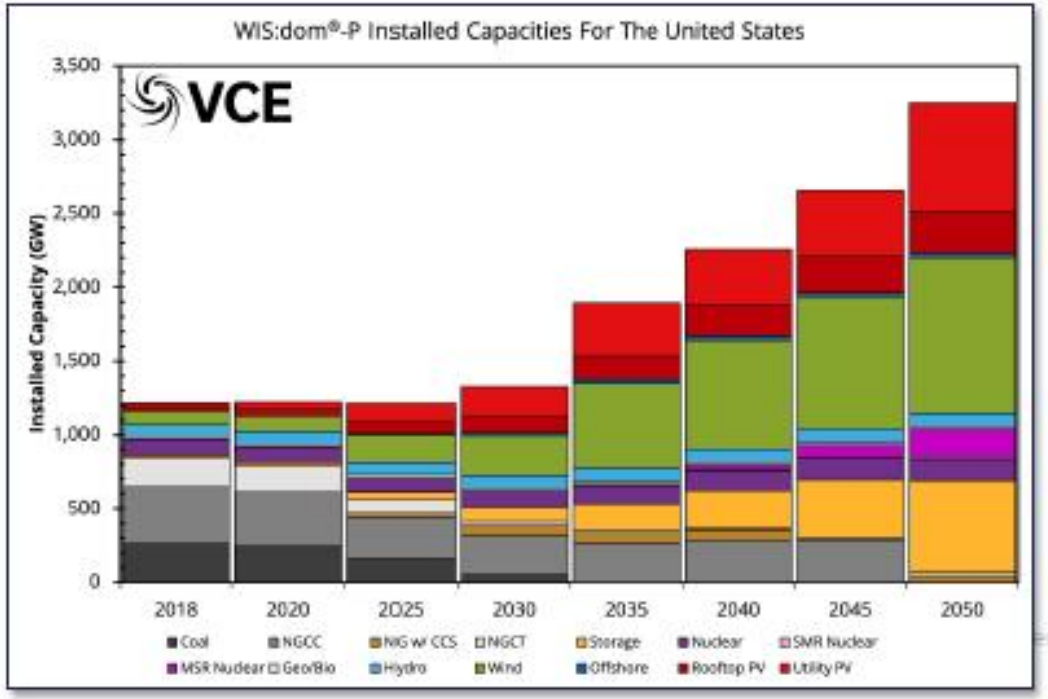
Decarbonization requires action on a transformative scale



We need transmission to *deliver* significant resources

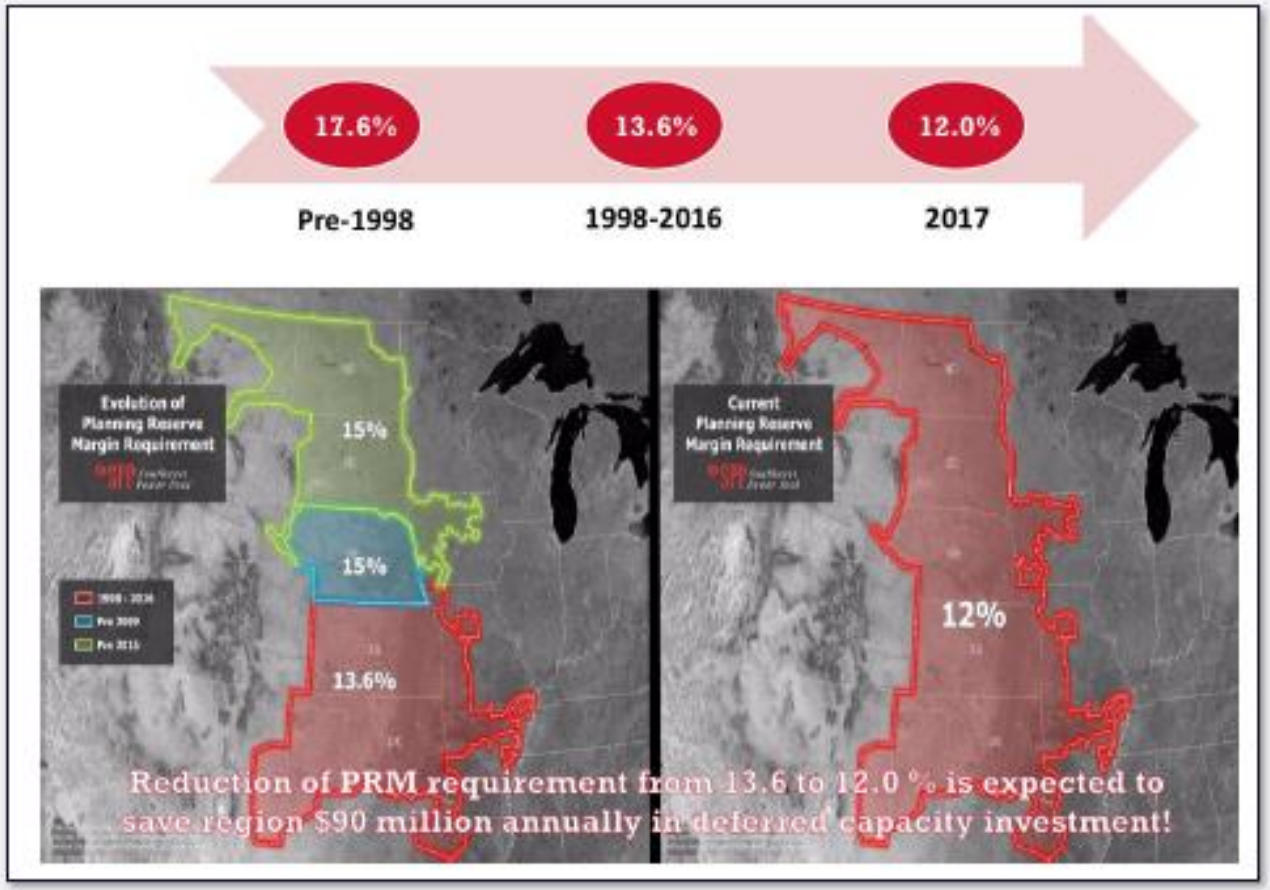
- We may need 1000 GW+ of new wind and solar to meet 100% clean electricity goals
- Electrification will lead to significantly increased demand
- Distributed energy resources will contribute but are not sufficient on their own
- We have 700 GW of zero carbon resources in interconnection queues across the US

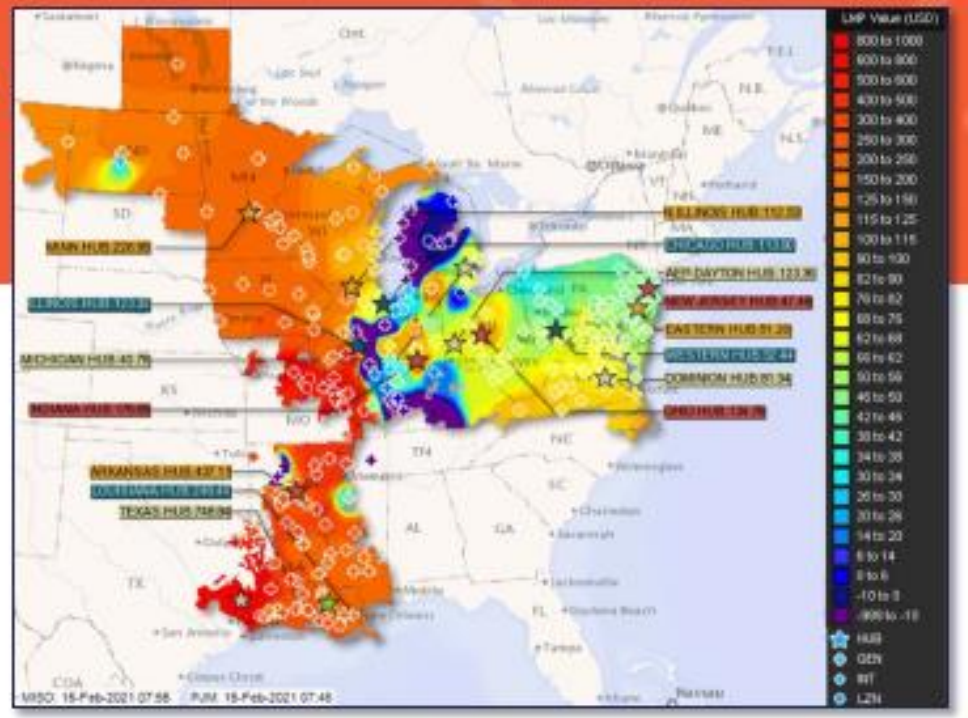


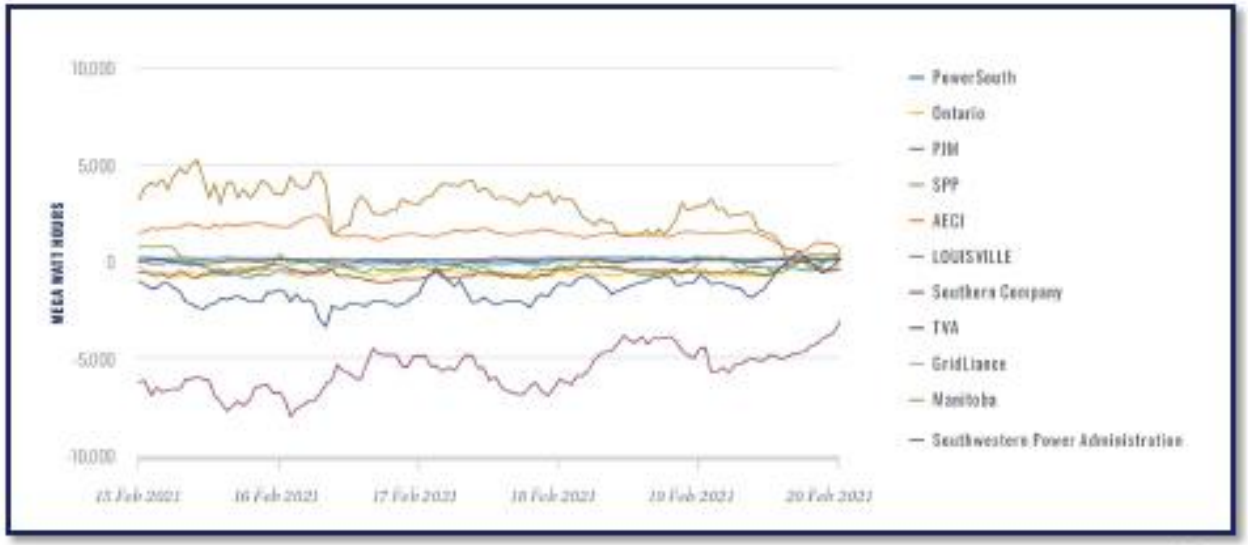


Vibrant Clean Energy, see Lew, et al, *Transmission Planning for 100% Clean Electricity*, IEEE PES Magazine, Nov/Dec 2021

We need transmission for resource adequacy and resilience

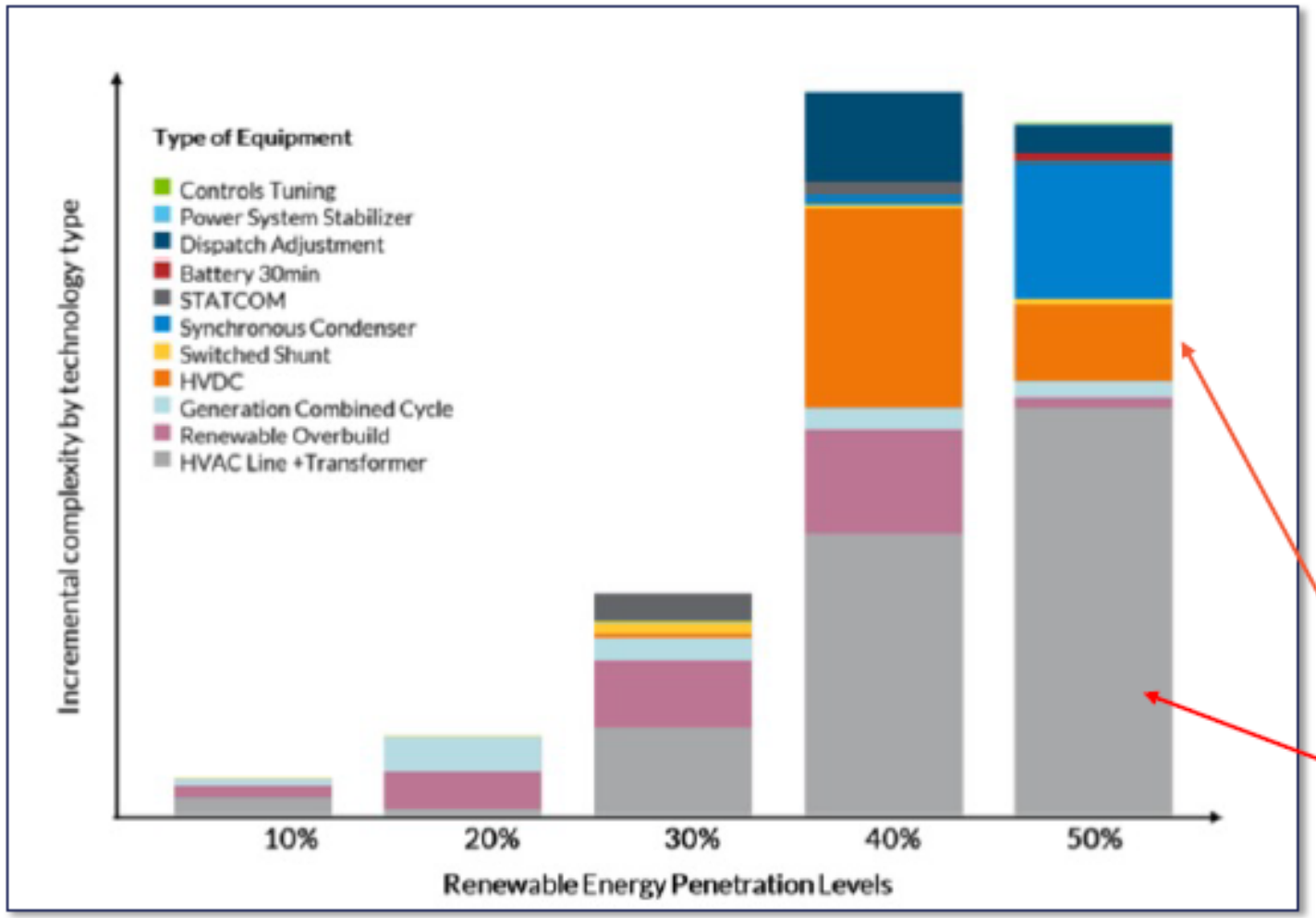






Nickell, SPP, WIEB CREPC Spring meeting, 2017; Joint and Common Market contour map, see Goggin, *Transmission Makes the Power System Resilient to Extreme Weather*, July 2021

We need transmission for a host of other reliability benefits



MISO's RIIA study found that transmission was the key enabler to meet reliability standards at 50% wind/solar

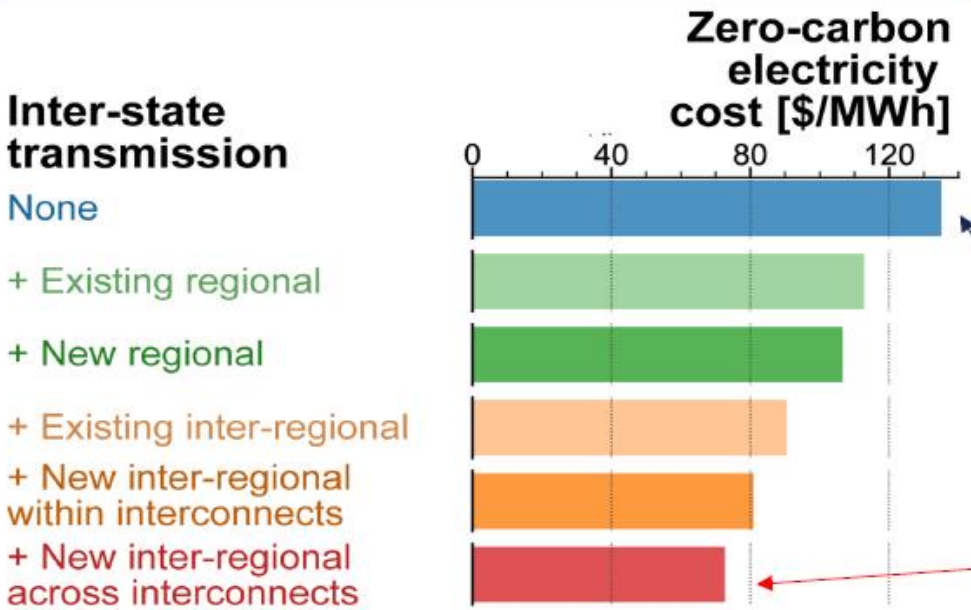
DC TRANSMISSION

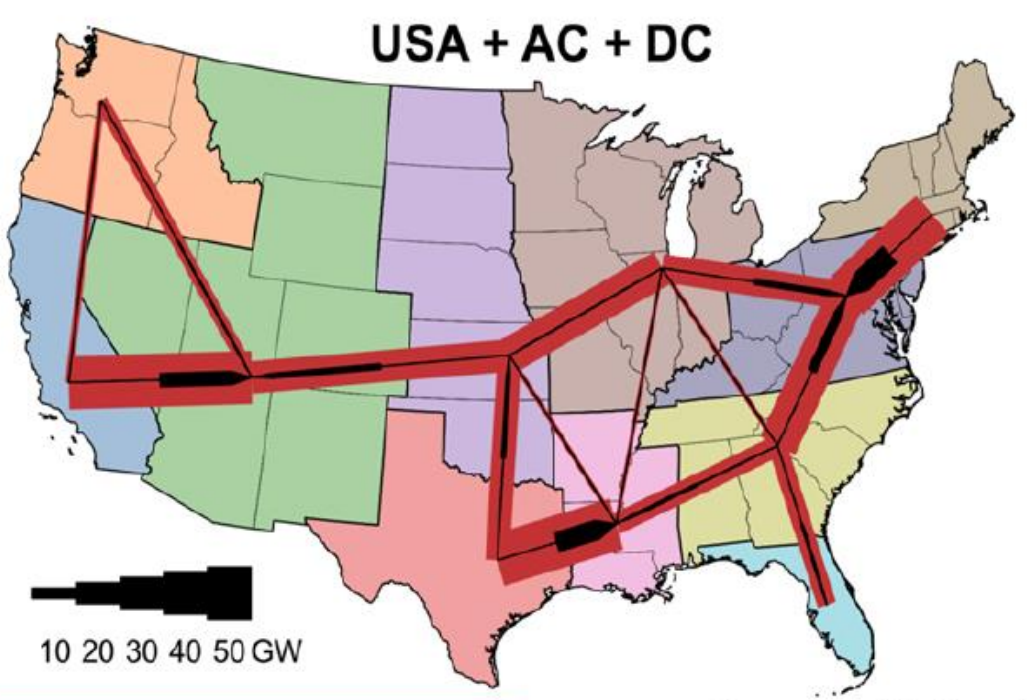
AC TRANSMISSION

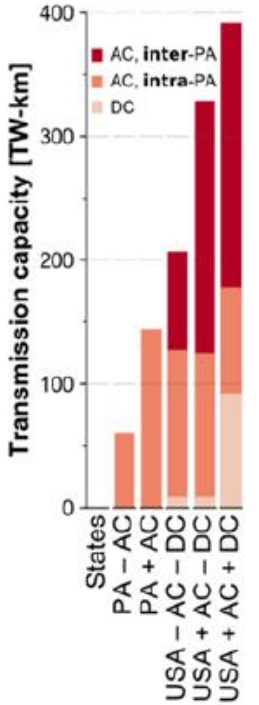
MISO, Renewable Integration Impact Assessment, Feb 2021

National transmission planning is needed

This study examines 100% clean electricity in the US under scenarios with increasing geographic levels of transmission expansion and operations





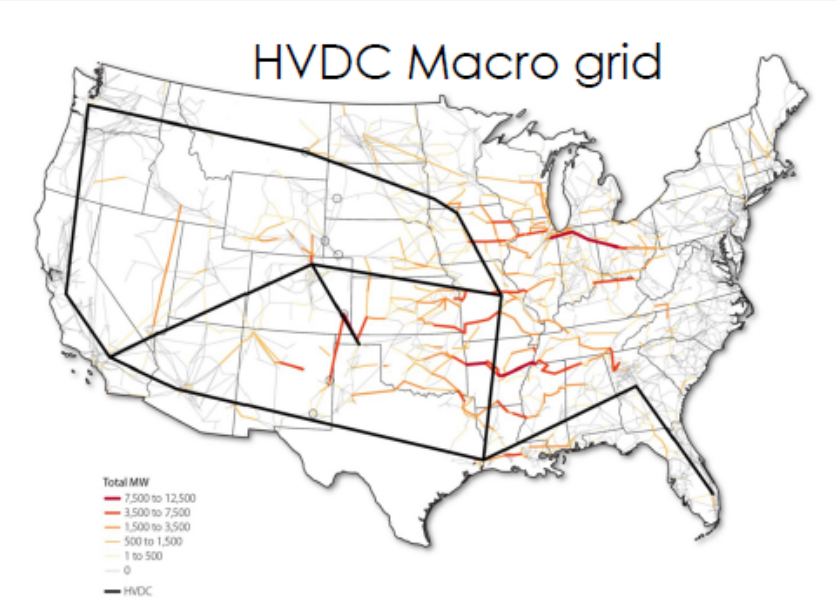


"Every state for itself" costs twice as much ($135/MWh) as the nationally optimized and coordinated approach ($73/MWh)

Brown and Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System," Joule 5, 1-20, Jan 20, 2021

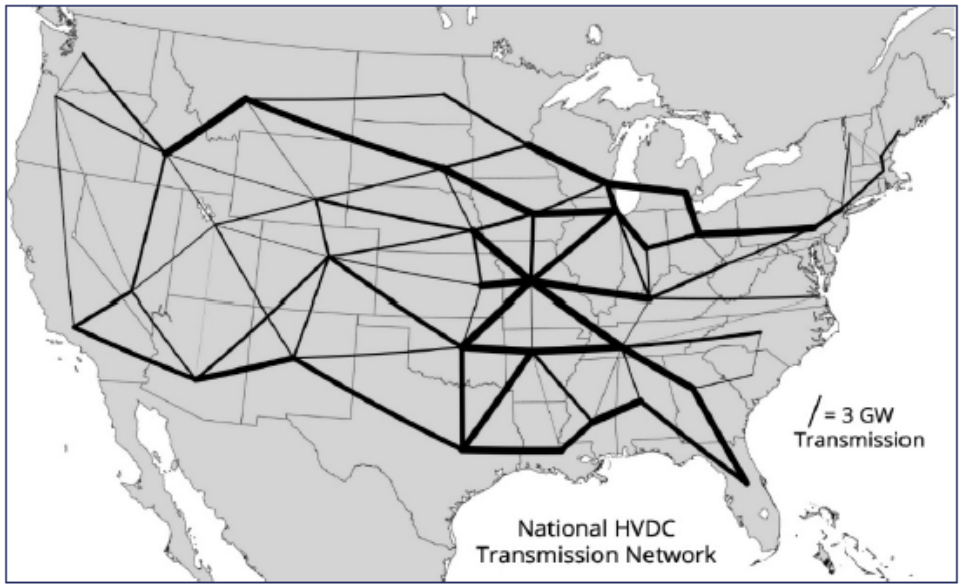
Stronger interconnection across the country saves money – especially with decarbonization

NREL Interconnection Seams Study



- With a 50% renewables goal, this HVDC macro grid has a benefit-to-cost ratio of 2.5
- With a 85% renewables goal, this HVDC macro grid has a benefit-to-cost ratio of 2.9

Vibrant Clean Energy ZeroByFifty

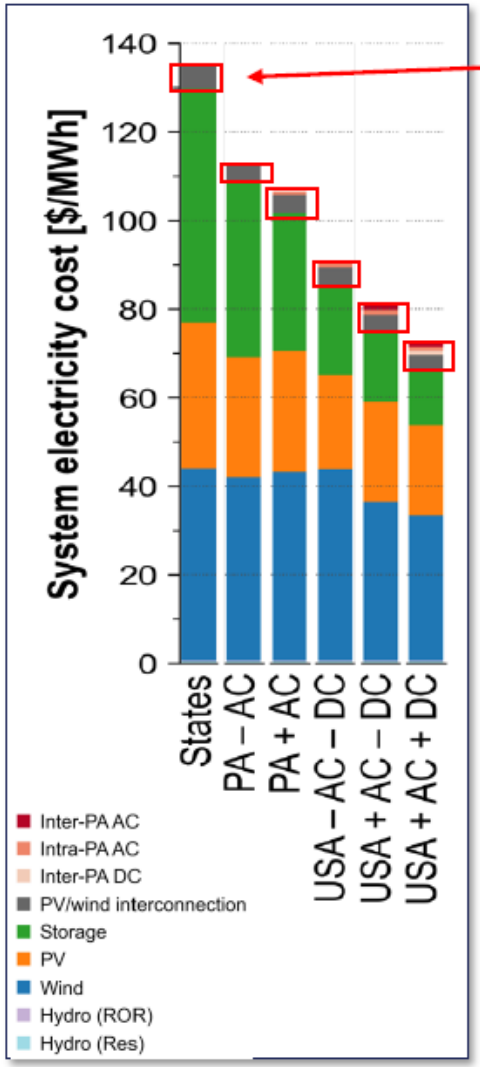


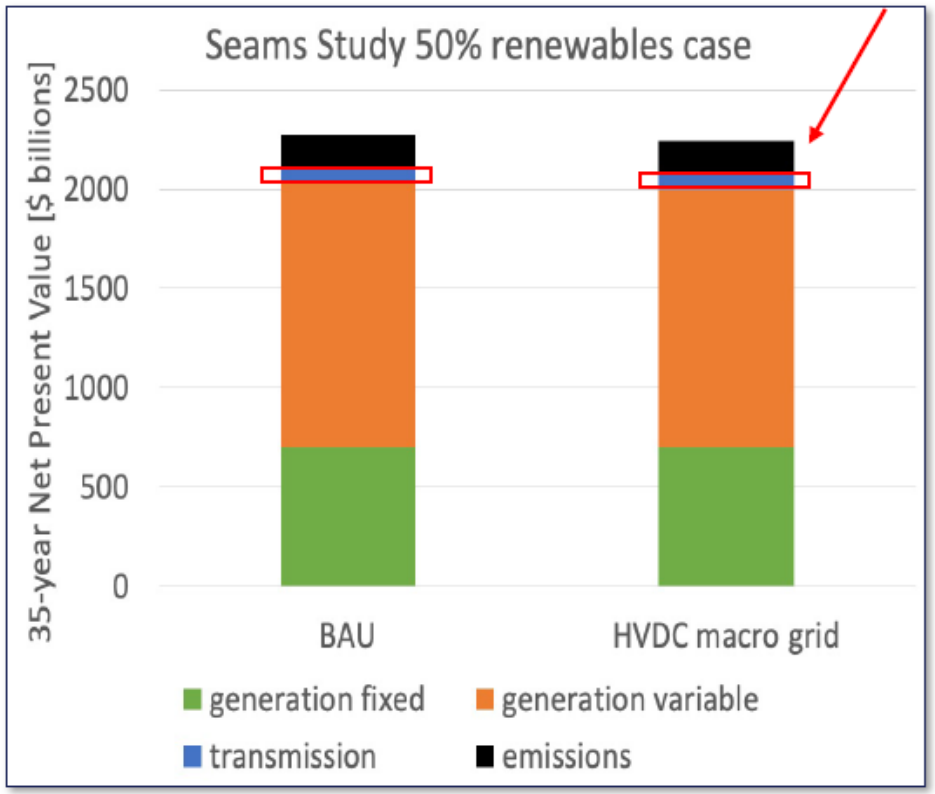
- Transmission expansion costs are $200B and $350B for 100% clean electricity and 100% clean energy, respectively
- If a macrogrid is not built, it costs $1T more to get to 100% clean energy by 2050

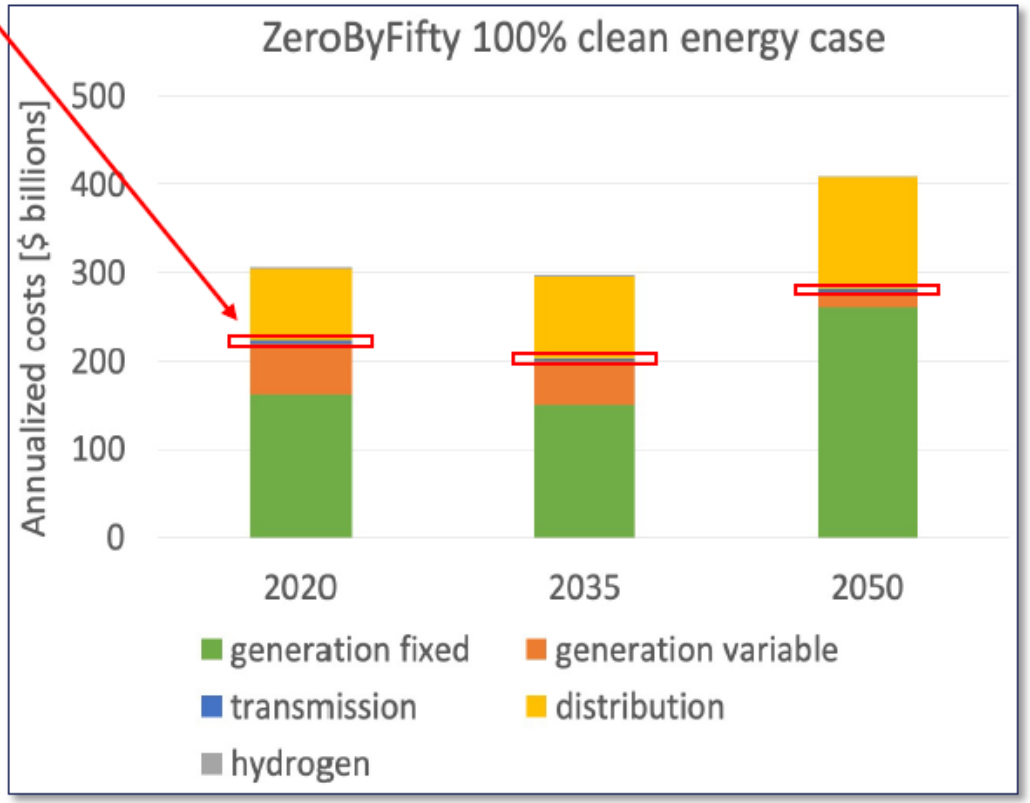
Figueroa Acevedo, et al, *Design and Valuation of High-Capacity HVDC Macrogrid Transmission for the Continental US*, IEEE Transactions on Power Systems, Vol 36, no 4, July 2021; VCE, see Lew, et al, *Transmission Planning for 100% Clean Electricity*, IEEE PES Magazine, Nov/Dec 2021

Transmission costs are ***tiny*** compared to other resource/infrastructure costs

TRANSMISSION COSTS





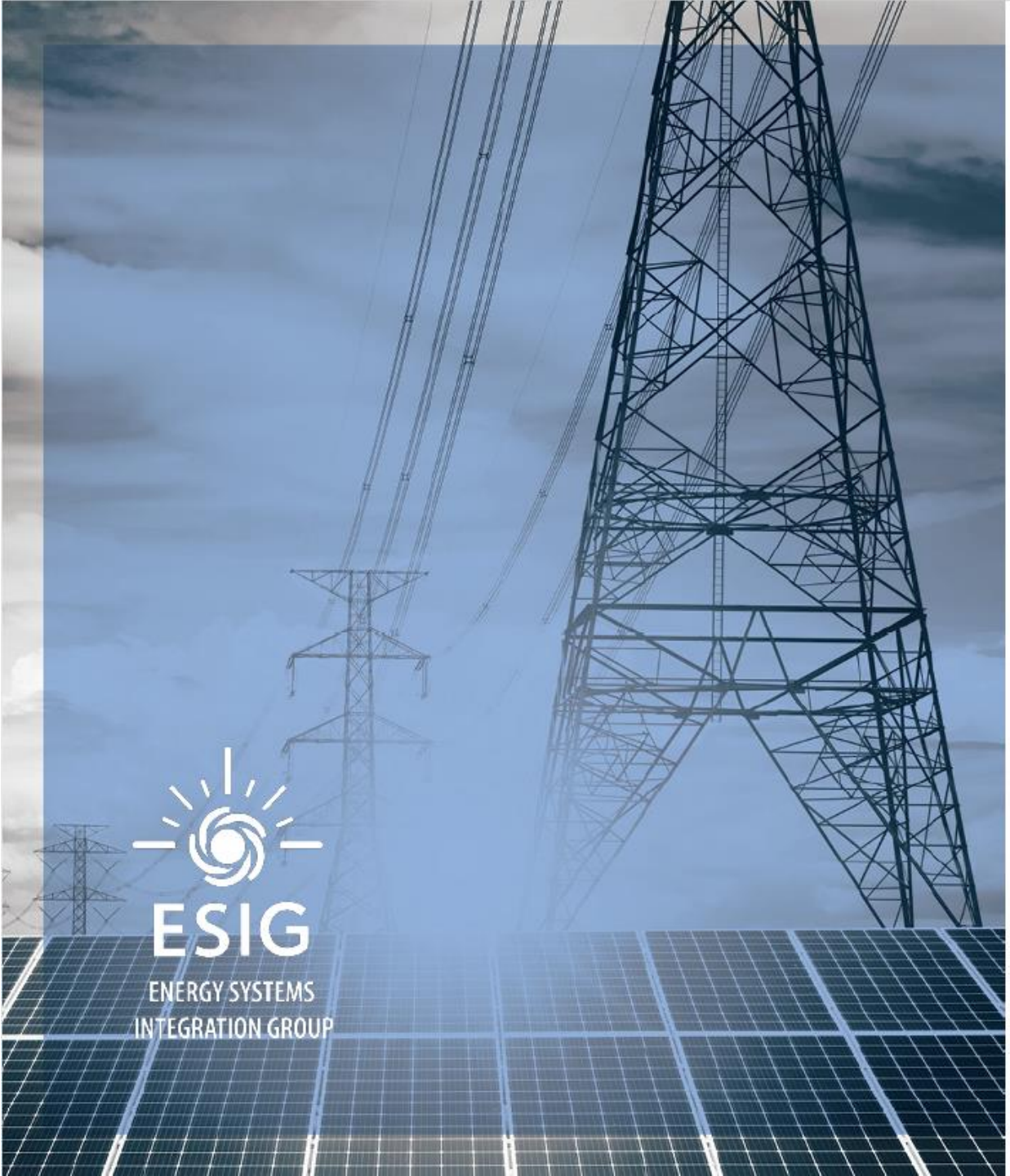


Brown and Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System," Joule 5, 1-20, Jan 20, 2021; data from NREL Interconnection Seams Study; data from VCE's ZeroByFifty Study

ESIG recommendations

- **We need ongoing national transmission planning, not just a one-off study**
- **We need to proactively plan and build transmission to high quality clean energy zones**
- **We need to design and evaluate performance of a national macro grid for reliability, resilience, operations and economics**

https://www.esig.energy/design-study-requirements-for-a-u-s-macrogrid/
https://www.esig.energy/transmission-planning-for-100-clean-electricity/



THANK YOU

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Lauren Azar

Owner, Advisor

Azar Law LLC

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

STATES WORKING TOGETHER SAVE CUSTOMERS MONEY

How states, working together, can cost-effectively address the nation's changing generation portfolio

LAUREN AZAR

DOE'S NATIONAL TRANSMISSION PLANNING STUDY WEBINAR

MARCH 15, 2022

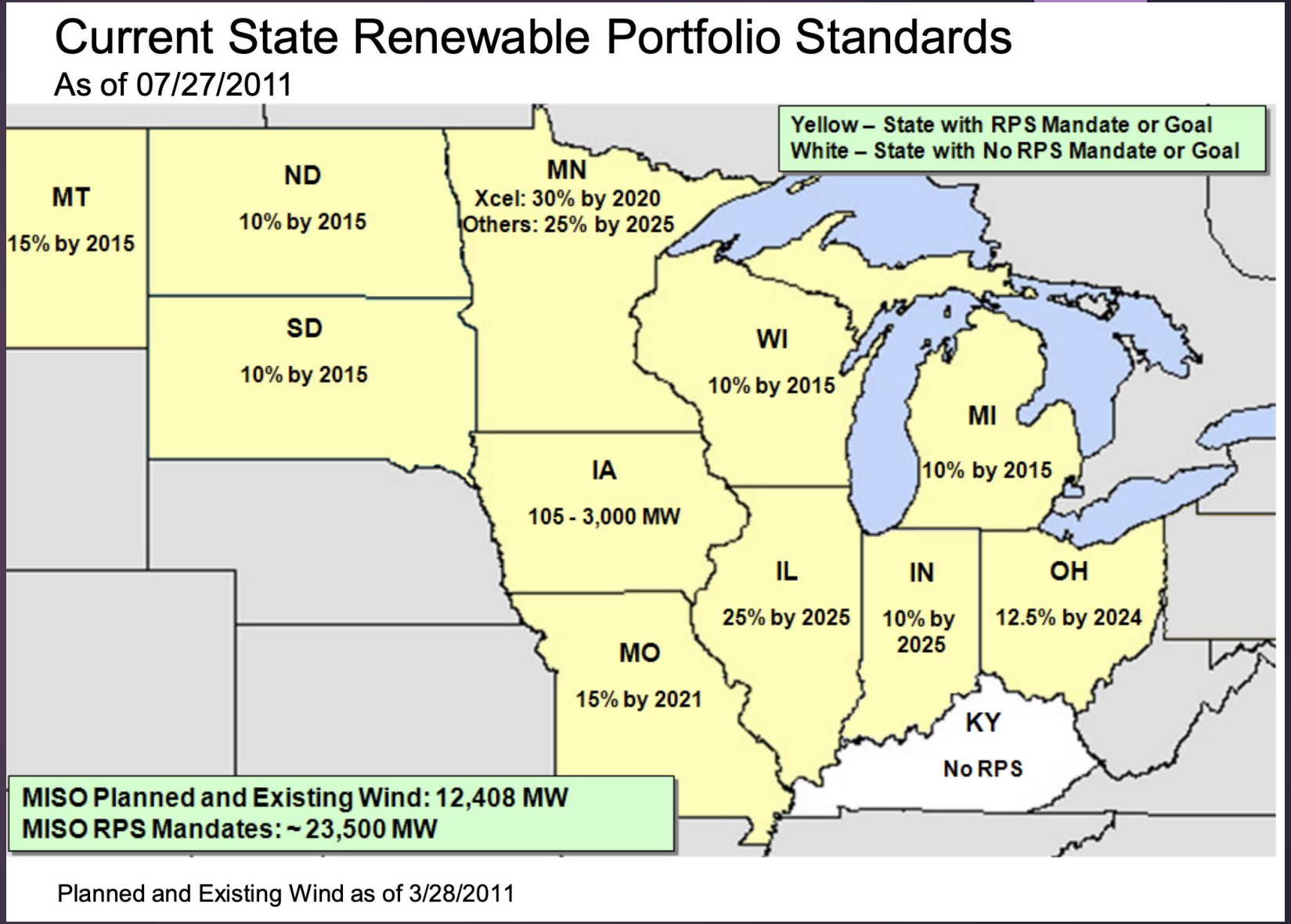
1. MISO's Multi-Value Projects (MVPs) of 2011

2. MISO's Long-Range Transmission Planning (LRTP) of 2021/2022

3. MISO and SPP's Joint Targeted Interconnection Queue Study (JTIQ) of 2021/2022

MVPs:

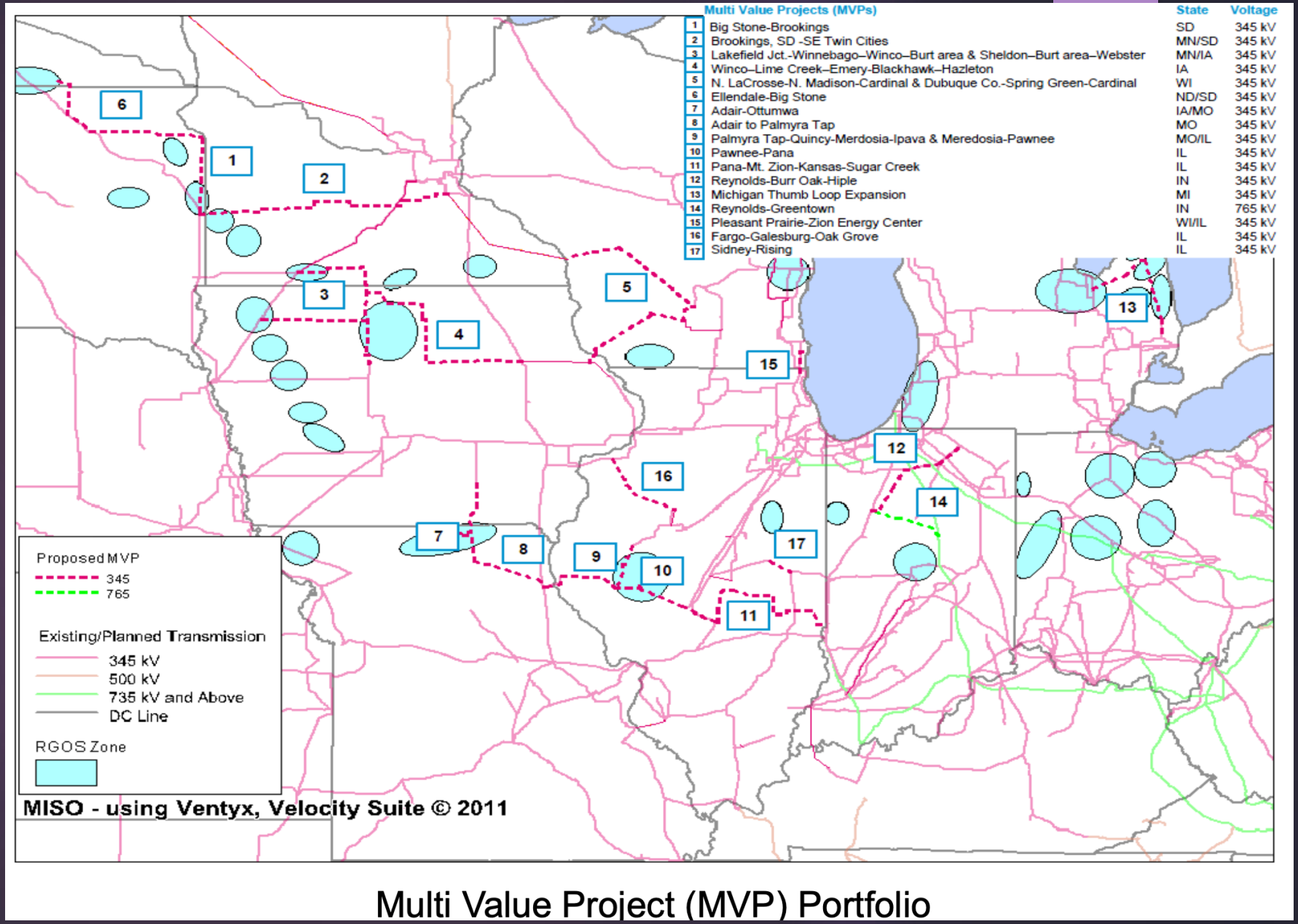
States asked MISO to enable RPS compliance



Source: MISO MVP Portfolio Detailed Business Case, p. 8

MVPs:

MISO's 2011 Renewable Energy Zones and 17 Lines

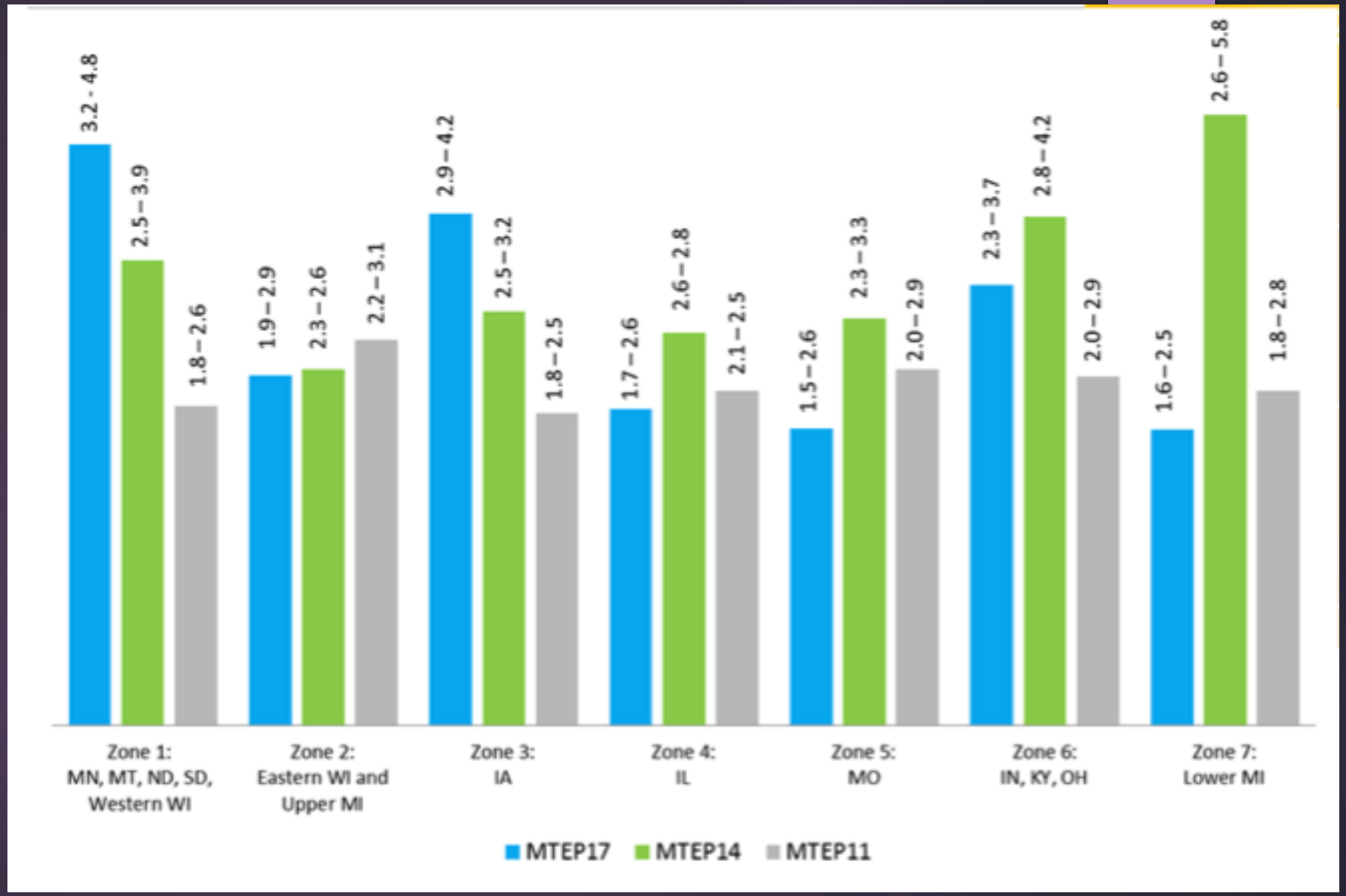


Multi Value Project (MVP) Portfolio

Source: MISO MVP Portfolio Results and Analysis 1/10/2012, Figure 1.1

MVPs:

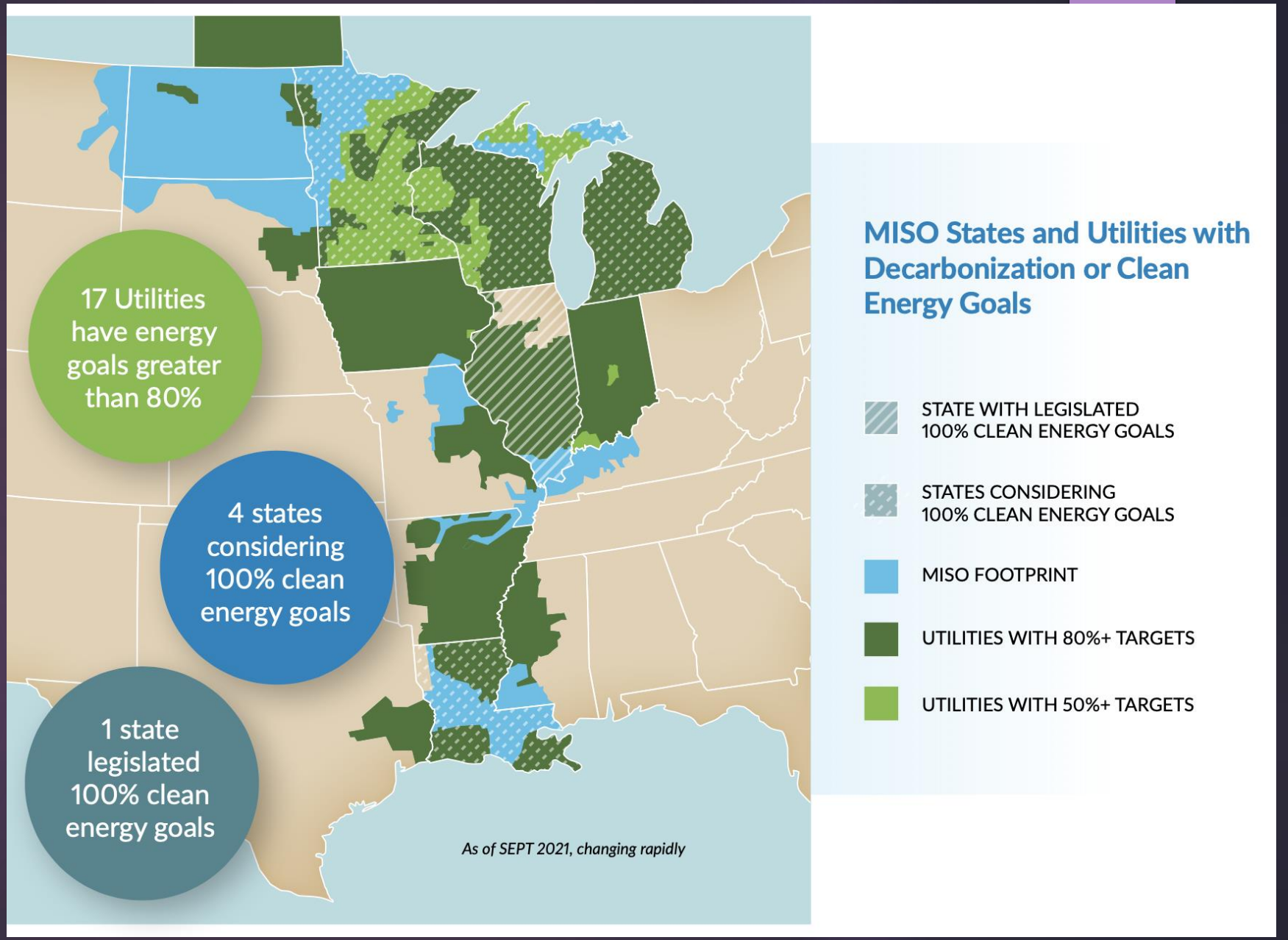
Benefits Change Over Time but Outweigh Costs



Source: Figure E-3, MISO MVP 2017 Triennial Review Report, retrieved at https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf

LRTP:

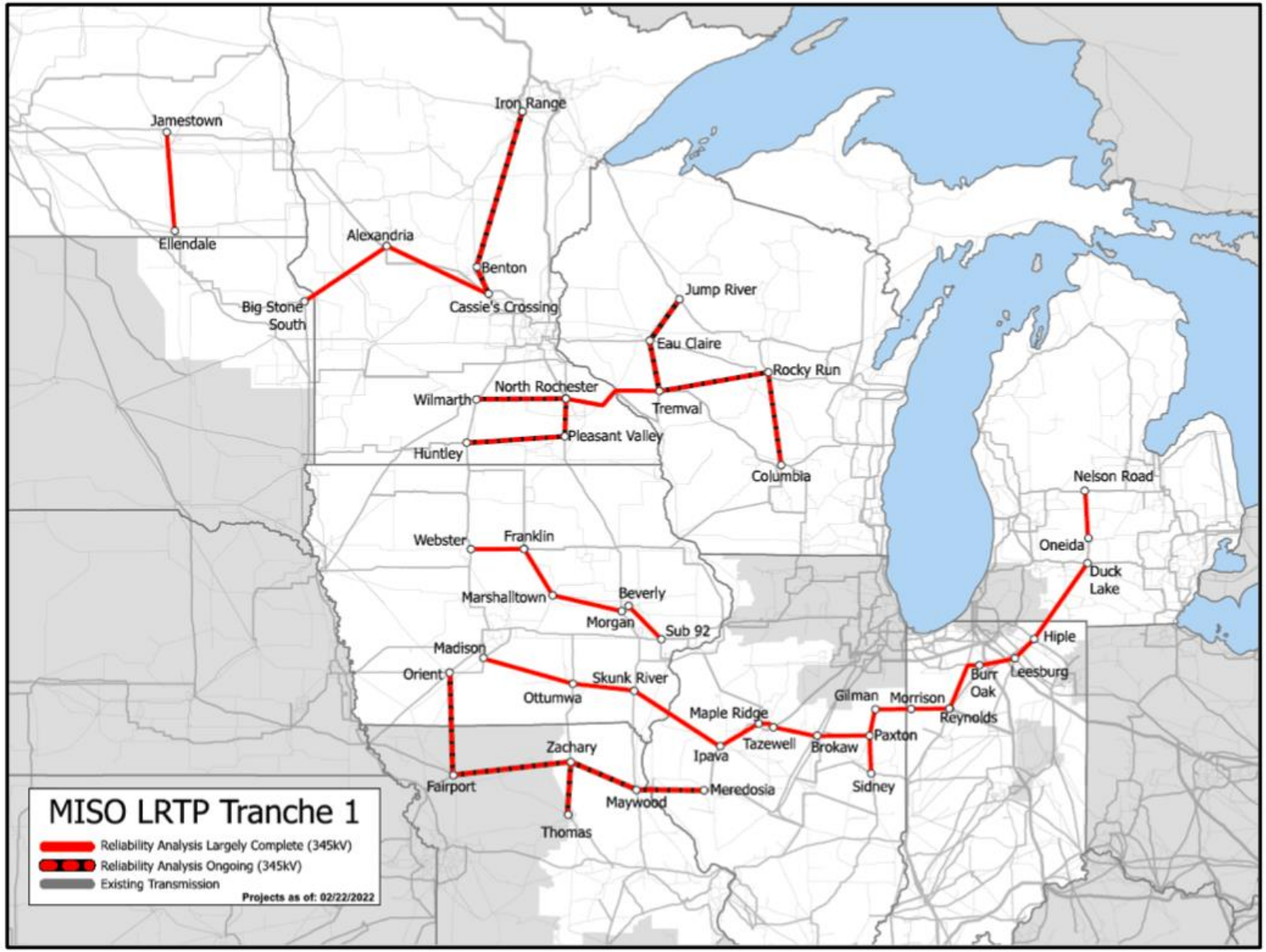
State and Utility Goals in 2021



Source: MISO MTEP21 Full Report, p. 7.

LRTP:

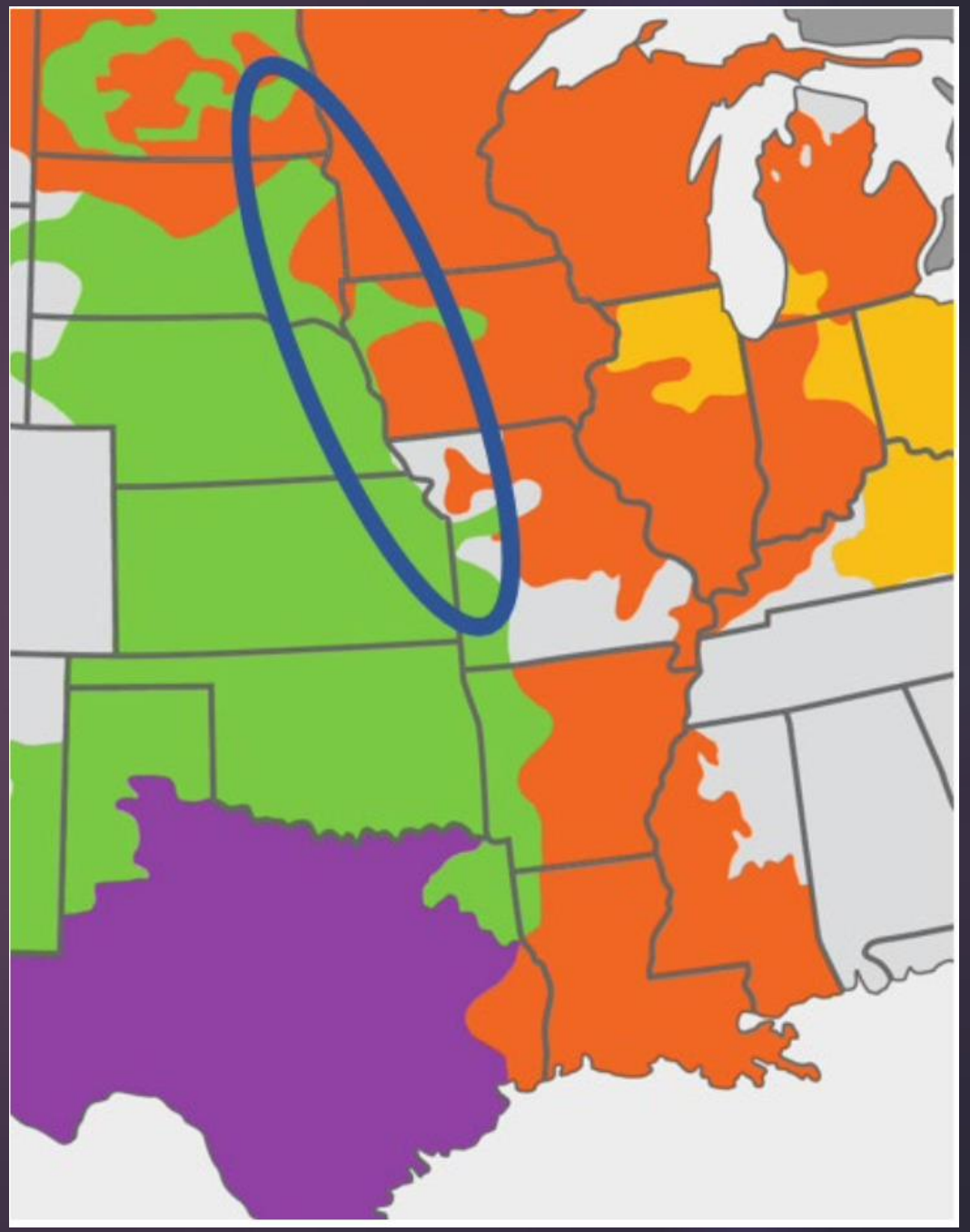
Tranche 1 – as of 2/22/22



Source: LRTP Workshop, slide 2, retrieved at https://cdn.misoenergy.org/20220225%20LRTP%20Workshop%20Item%2002%20Tranche%201%20Reliability%20Analysis%20Presentation623078.pdf

JTIQ:

The MISO-SPP Seam is Preventing New Interconnections



Source: JTIQ Final Report March 2022 retrieved at https://cdn.misoenergy.org/JTIQ%20Report623262.pdf

JTIQ:

Report identified potential solutions

Figure 2: JTIQ Portfolio Map

Source: JTIQ Final Report March 2022 retrieved at https://cdn.misoenergy.org/JTIQ%20Report623262.pdf

CONCLUSIONS

1. Regional and interregional lines will:
   - enable the most cost-effective transformation of the generation portfolio, AND
   - bolster regional reliability and resilience.

2. These regional and interregional solutions can only be realized if states work together.

3. States taking a parochial approach--refusing to work with their neighbors--will unnecessarily force consumers to pay more for their electricity resulting in unjust and unreasonable rates.

Johannes Pfeifenberger

Principal

Brattle

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

The Benefits of Interregional Transmission: Grid Planning for the 21st Century

PRESENTED BY

Johannes Pfeifenberger

PREPARED FOR

Building a Better Grid Initiative

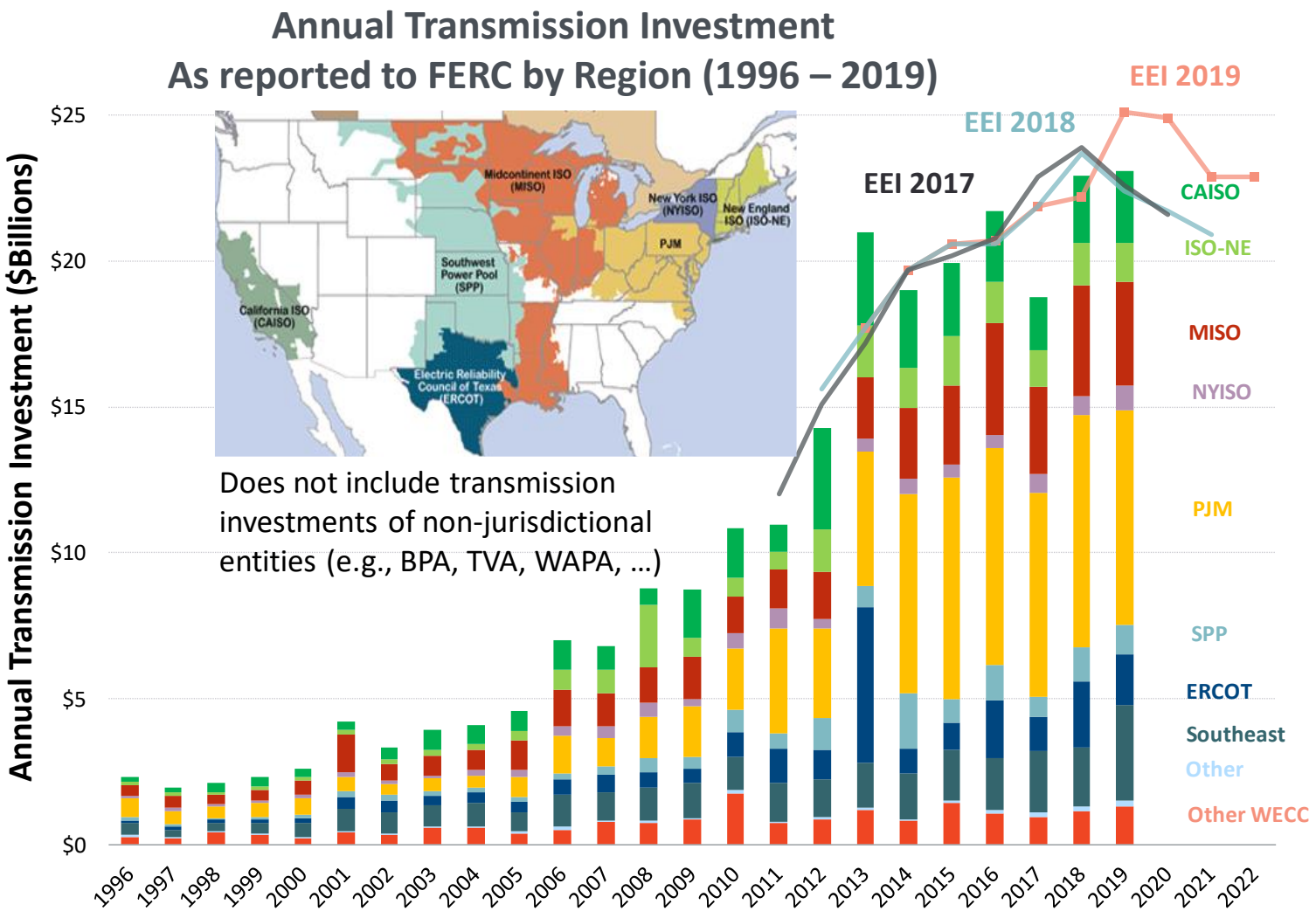
DOE Office of Electricity

March 15, 2022

Brattle

Contents

Transmission Investment is at Historically High Levels

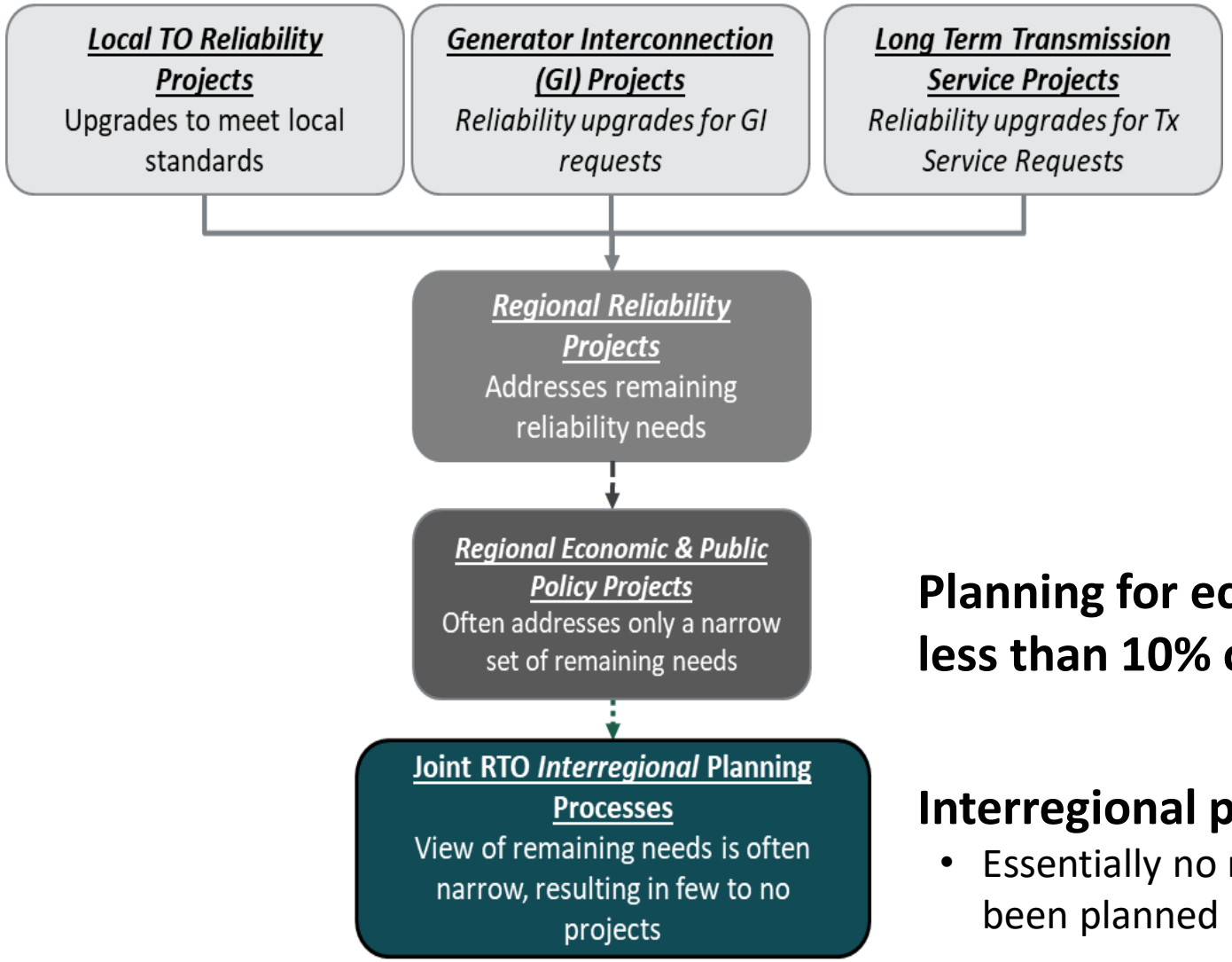


Source: FERC Form 1 Data, EEI "Historical and Projected Transmission Investment" most recent accessed here: https://www.eei.org/resourcesandmedia/Documents/Historical%20and%20Projected%20Transmission%20Investment.pdf

$20-25 billion in annual U.S. transmission investment, 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 and overall cost savings

Current U.S. Grid Planning Processes are Siloed



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)
- Which also means these investments are not made with the objective to find the most cost-effective solutions
- Will yield higher system-wide costs and electricity rates

Planning for economic and public-policy projects: less than 10% of all transmission investments

Interregional planning processes are large ineffective

- Essentially no major interregional transmission projects have been planned and built in the last decade

Barriers to Regional and Interregional Transmission Planning

A. Leadership, Alignment and Understanding	1. Insufficient leadership from RTOs and federal & state policy makers to prioritize interregional planning 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

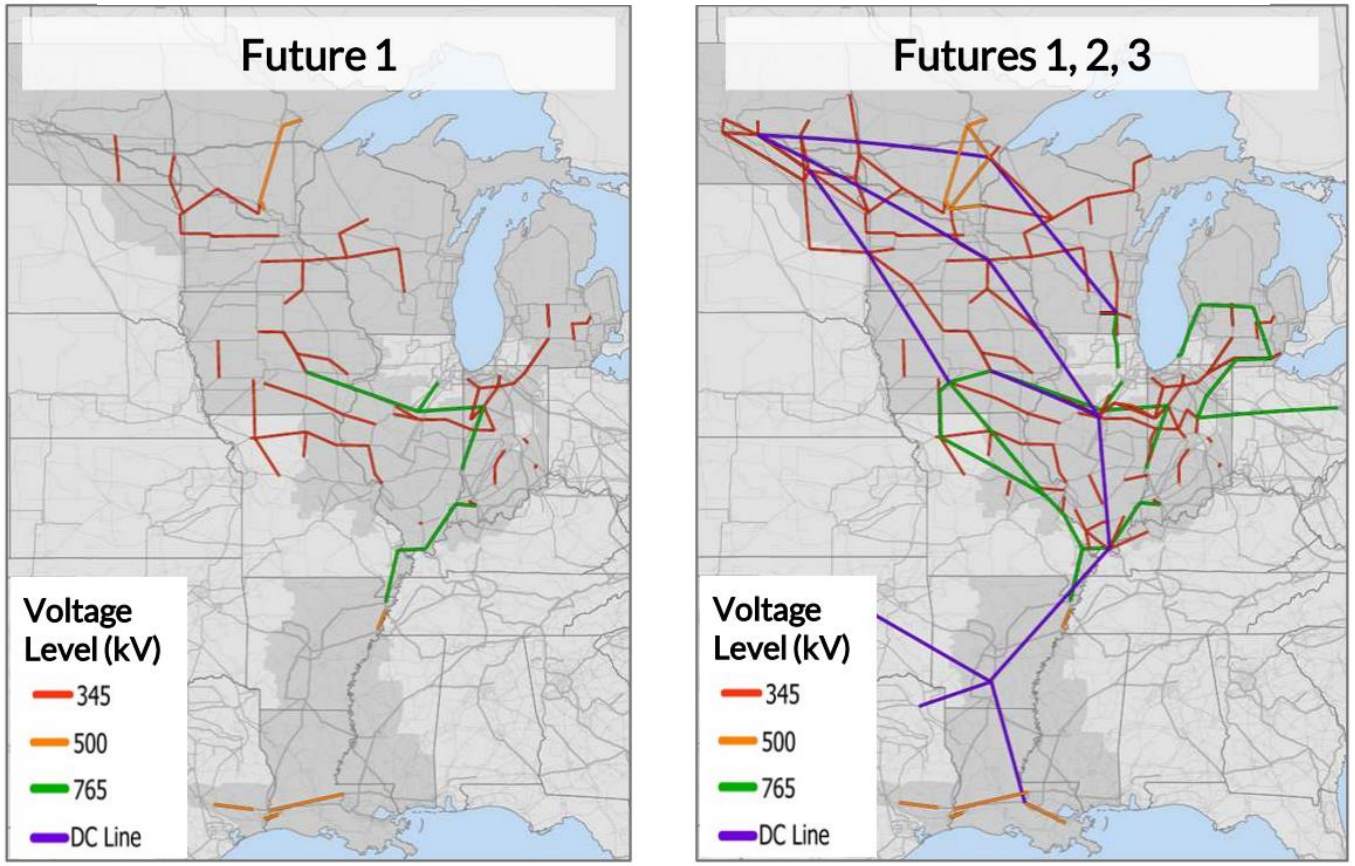
Source: Appendix A of A Roadmap to Improved Interregional Transmission Planning, November 30, 2021. Based on interviews with 18 organizations representing state and federal policy makers, state and federal regulators, transmission planners, transmission developers, industry groups, environmental groups,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

Example (B8): Prioritizing Regional over Interregional Solutions

- MISO's new Renewable Integration Impact Assessment (RIIA) improves on many other planning studies by:
  - Establishing the need to study both policy goals and reliability goals simultaneously
  - Considering diverse future scenarios
  - Recommends a "least-regret" transmission plan (but one that does not address possibility of regret from inadequate T)
- By design, **the scope of study does not address any interregional opportunities:**
  - Despite modeling five regions in addition to MISO, the study mostly did not consider interregional transmission (see figures)
  - Even if "optimal" for MISO, it likely preempts more cost-effective interregional solutions

How would SPP-MISO-PJM wide planning results differ?

MISO's projected scope of transmission expansion needs



Source: MISO LRTP Roadmap March 2021

Understanding Transmission-Related Benefits

Wide-spread nature of benefits creates challenges in estimating them and how they accrue to different users, which also complicates cost allocation

▪ **Broad in scope, providing many different types of benefits**	• Increased reliability and operational flexibility • Reduced congestion, dispatch costs, and losses • Lower capacity needs and generation costs • Increased competition and market liquidity • Renewables integration and environmental benefits • Insurance and risk mitigation benefits • Diversification benefits (e.g., reduced uncertainty and variability) • Economic development from G&T investments
▪ **Wide-spread geographically**	• Multiple transmissions service areas • **Multiple states** or regions
▪ **Diverse in their effects on market participants**	• **Customers**, **generators**, **transmission owners** in regulated and/or deregulated markets • Individual market participants may capture one set of benefits but not others
▪ **Occur and change over long periods of time**	• Several decades (50+ years), typically increasing over time • Changing with system conditions and future generation and transmission additions • Individual market participants may capture different types of benefits at different times

Economic benefit of transmission =

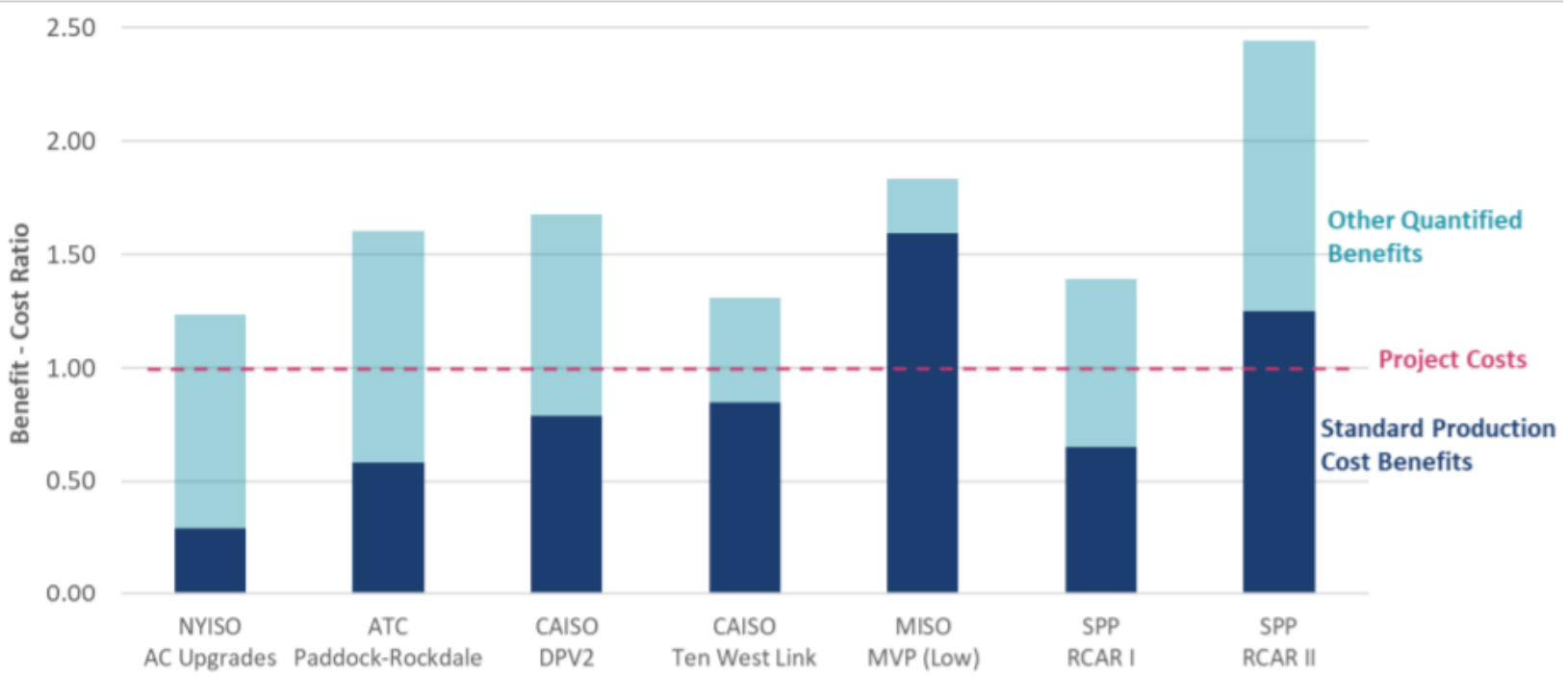
+ Cost savings that reduce overall system-wide costs faced by customers

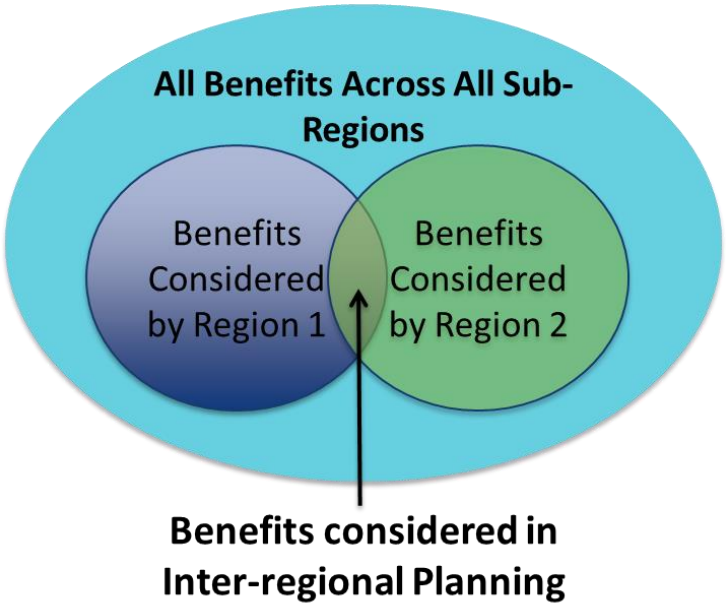
+ Economic value of added reliability

Quantifying Benefits Beyond "Production Cost" Savings

Relying solely on traditionally-quantified Adjusted Production Cost (APC) Savings results in the rejection of beneficial transmission projects – particularly for interregional planning efforts that consider an even smaller subset of benefits:

FIGURE 5. BENEFIT-COST RATIOS OF TRANSMISSION PROJECTS WITH AND WITHOUT A BROAD SCOPE OF BENEFITS





Source: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs
A Roadmap to Improved Interregional Transmission Planning.

We have a Decade of Experience with Identifying and Quantifying a Broad Range of Transmission Benefits

SPP 2016 RCAR, 2013 MTF

Quantified

1. **production cost savings***
   - value of reduced emissions
   - reduced ancillary service costs
2. avoided transmission project costs
3. reduced transmission losses*
   - capacity benefit
   - energy cost benefit
4. lower transmission outage costs
5. value of reliability projects
6. value of mtg public policy goals
7. Increased wheeling revenues

Not quantified

8. reduced cost of extreme events
9. reduced reserve margin
10. reduced loss of load probability
11. increased competition/liquidity
12. improved congestion hedging
13. mitigation of uncertainty
14. reduced plant cycling costs
15. societal economic benefits

(SPP Regional Cost Allocation Review Report for RCAR II, July 11, 2016. SPP Metrics Task Force, *Benefits for the 2013 Regional Cost Allocation Review*, July, 5 2012.)

MISO MVP Analysis

Quantified

1. **production cost savings** *
2. reduced operating reserves
3. reduced planning reserves
4. reduced transmission losses*
5. reduced renewable generation investment costs
6. reduced future transmission investment costs

Not quantified

7. enhanced generation policy flexibility
8. increased system robustness
9. decreased natural gas price risk
10. decreased CO_2 emissions output
11. decreased wind generation volatility
12. increased local investment and job creation

(Proposed Multi Value Project Portfolio, Technical Study Task Force and Business Case Workshop August 22, 2011)

CAISO TEAM Analysis

(DPV2 example)

Quantified

1. **production cost savings*** and reduced energy prices from both a societal and customer perspective
2. mitigation of market power
3. insurance value for high-impact low-probability events
4. capacity benefits due to reduced generation investment costs
5. operational benefits (RMR)
6. reduced transmission losses*
7. emissions benefit

Not quantified

8. facilitation of the retirement of aging power plants
9. encouraging fuel diversity
10. improved reserve sharing
11. increased voltage support

(CPUC Decision 07-01-040, January 25, 2007, Opinion Granting a Certificate of Public Convenience and Necessity)

NYISO PPTN Analysis

(AC Upgrades)

Quantified

1. **production cost savings*** (includes savings not captured by normalized simulations)
2. capacity resource cost savings
3. reduced refurbishment costs for aging transmission
4. reduced costs of achieving renewable and climate policy goals

Not quantified

5. protection against extreme market conditions
6. increased competition and liquidity
7. storm hardening and resilience
8. expandability benefits

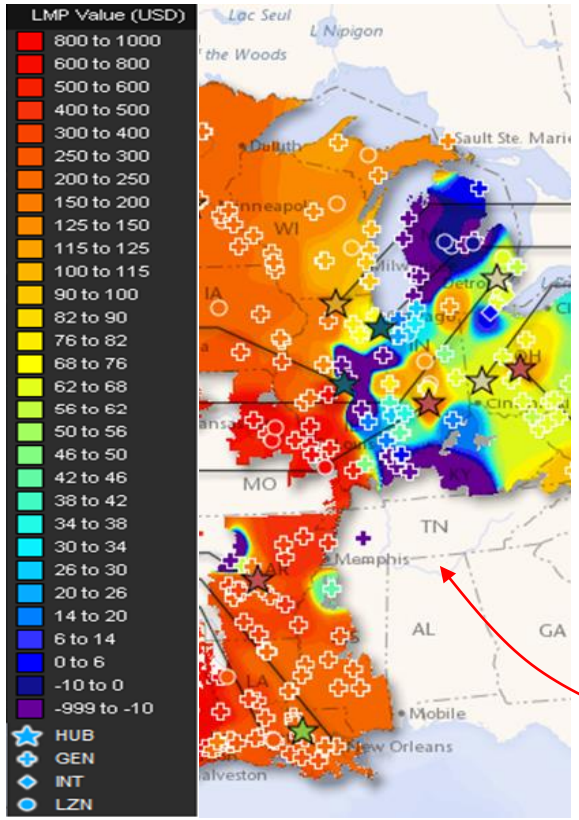
(Newell, et al., Benefit-Cost Analysis of Proposed New York AC Transmission Upgrades, September 15, 2015)

* Fairly consistent across RTOs

Interregional Reliability Benefits: Winter Storm Uri

Transmission constraints led to substantial price separations. An additional GW of transmission into Texas would have fully paid for itself over the course of the four-day event (Goggin, 2021).

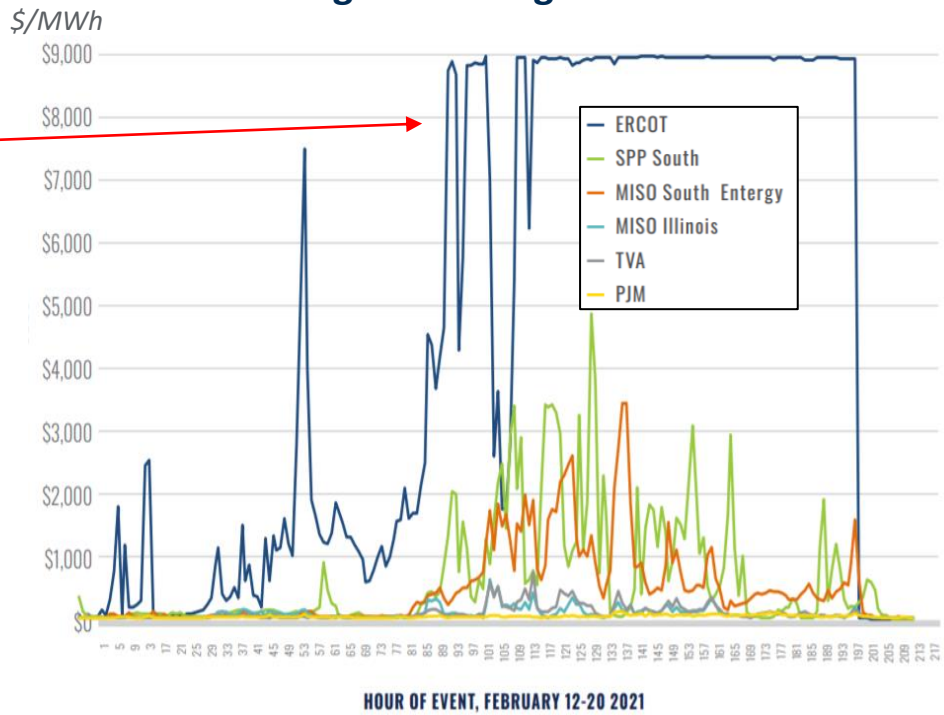
MISO LMPs on Feb 15th, 2021 at 7:45-7:55



Savings per 1000 MW of Additional Interregional Transmission Capability
($ millions)

ERCOT – TVA	$993
SPP South – PJM	$129
SPP South – MISO IL	$122
SPP South – TVA	$120
SPP S – MISO S (Entergy Texas)	$110
MISO S-N (Entergy Texas - IL)	$85
MISO S (Entergy Texas) – TVA	$82

Electricity Price Differences Between Regions During Uri



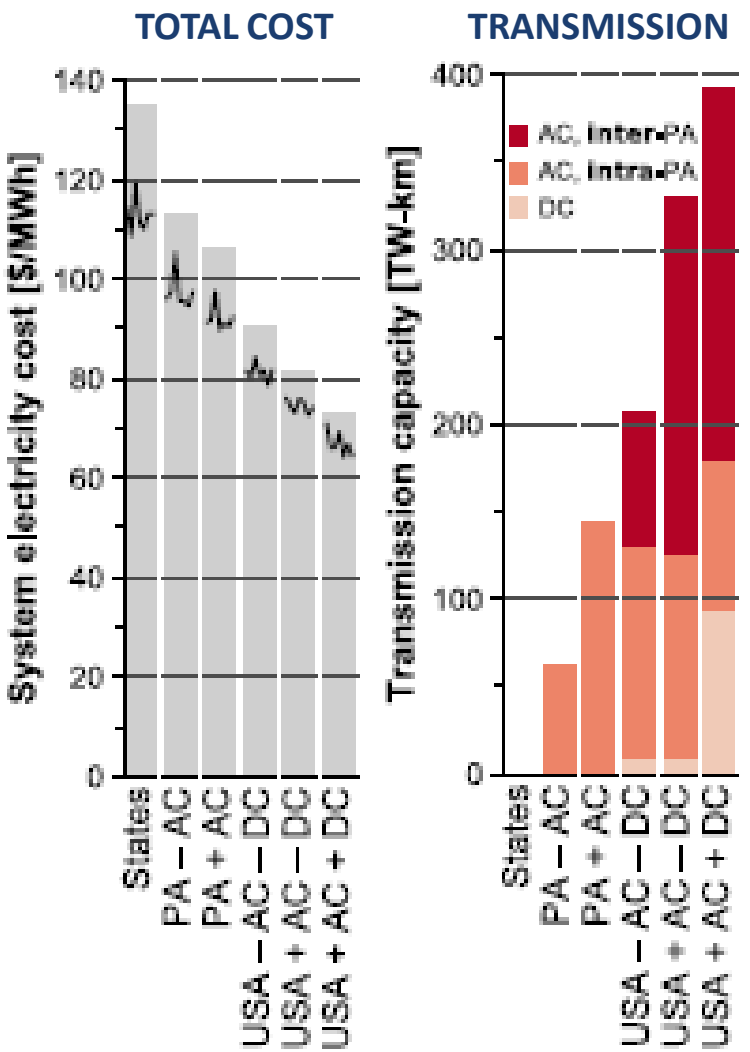
Brattle Reports on Transmission Benefit-Cost Analyses and Interregional Planning Summarize the Available Experience

National Studies Show Large Benefit of Interregional Transmission

Study	Region	Findings
NREL North American Renewable Integration Study (2021)	U.S., Canada, Mexico	• Increasing trade between countries can provide $10-30 billion in net benefits • **Interregional transmission expansion achieves up to $180 billion in net benefits**
MIT Value of Interregional Coordination (2021)	Nation-Wide	• National coordination of **reduces the cost of decarbonizing by almost 50% compared to no coordination between states** • The lowest-cost scenario builds almost 400 TW-km of transmission; including **roughly 100 TW-km of DC capacity between the interconnections** and over 200 TW-km of interregional AC capacity • **No individual state is better off implementing decarbonization alone** compared to national coordination of generation and transmission investment • Low storage and solar costs still result in significant cost effective interregional transmission
Princeton Net Zero America Study (2021)	Nation-Wide	• Achieving net-zero emissions by 2050 requires **700-1,400 TW-km of new transmission** • Investment in transmission needed ranges **$2-4 trillion dollars by 2050**
U.C. Berkeley 90% by 2035 (2020)	Nation-Wide	• The only national study that suggest relatively little interregional transmission would be needed to achieve 90% clean electricity. However, the study's simulation approach does not utilize more granular and well-established methods to properly value interregional transmission.
Vibrant Clean Energy Interconnection Study (2020)	Eastern Interconnect	• **40 to 90 TW-km of transmission is built by 2050** to meet climate goals • Transmission development can create **1-2 million jobs in the coming decades**, more than wind, storage, or distributed solar development • Transmission **reduces electricity bills by $60-90 per MWh**
Wind Energy Foundation Study (2018)	ERCOT, MISO, PJM, and SPP	• Transmission planners are not incorporating this rising tide of voluntary corporate renewable energy demand into plans to build new transmission
NREL Seams Study (2017)	Eastern and Western Interconnects	• Major new ties between interconnections **saves $4.5-$29 billion** over a 35 year period

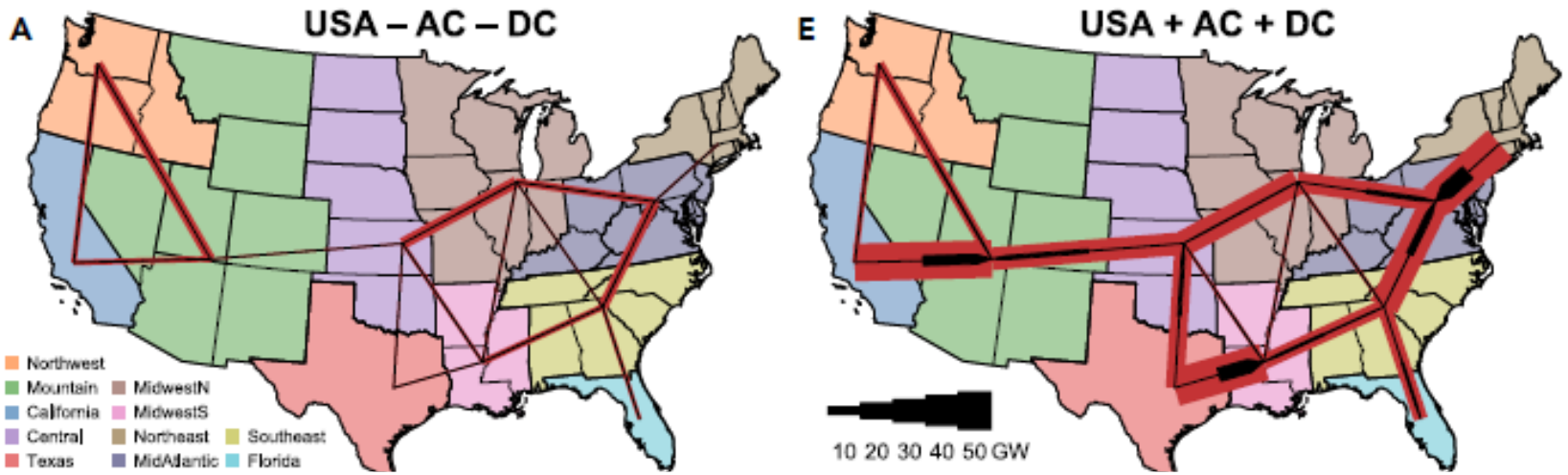
Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Example: MIT Value of Interregional Coordination (2021)



Key Result: A more robust national grid would reduce the total cost of decarbonizing the grid … but (higher-cost) regional and more local solutions may also be feasible

Optimal Transmission Build:
With and Without National Transmission Coordination



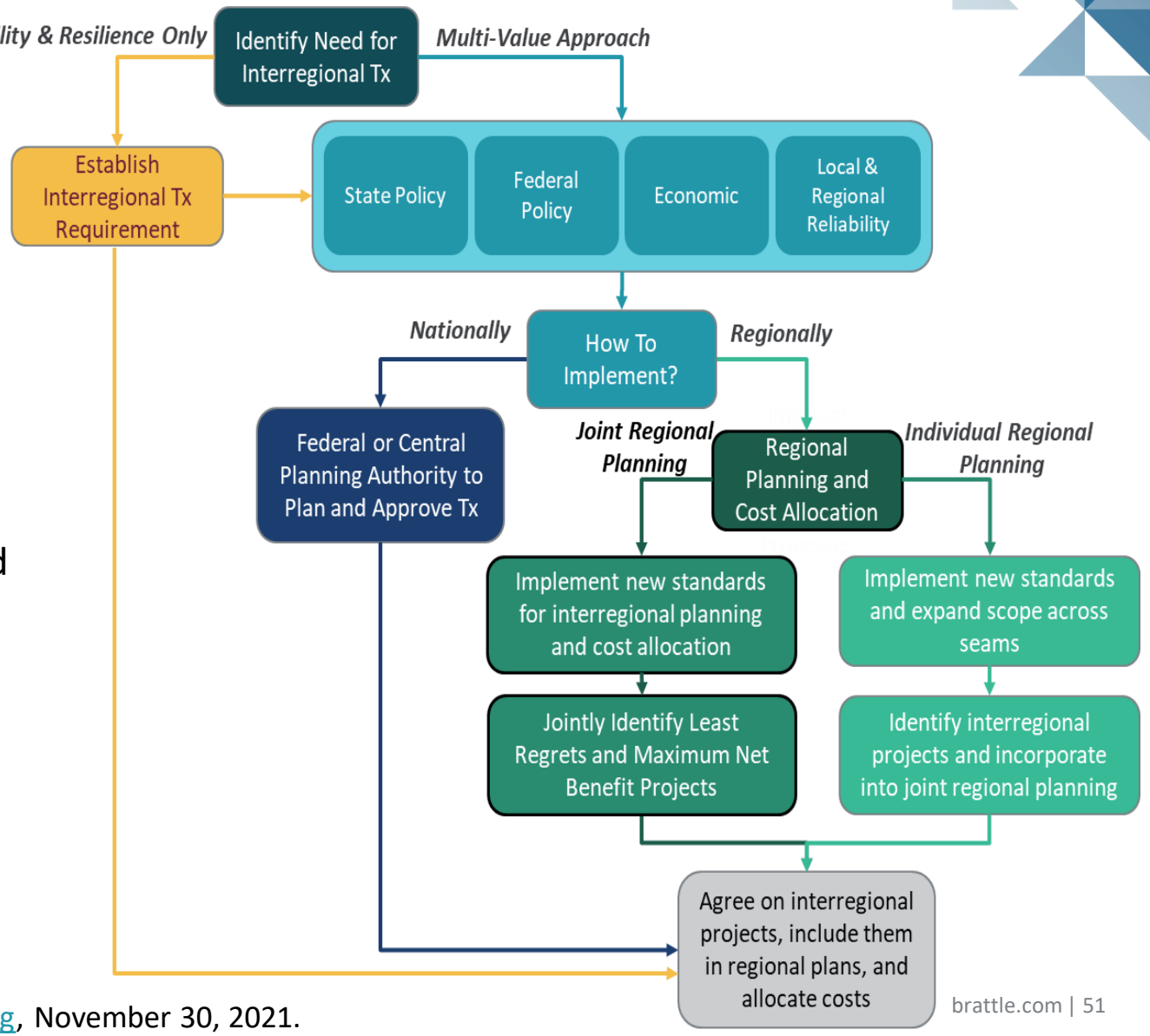
Limitations of National Studies

Although existing studies demonstrate the benefits of interregional transmission, they have not been successful in motivating improved interregional planning or 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** that produce specific transmission projects that can be developed to deliver the identified benefits and they **do not support an actionable need for specific 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 recovery options
  - 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 **propose actionable solutions** to address the many barriers to planning processes and to the development of new interregional transmission projects

Options for Improving Interregional Planning Processes

- While national studies show there are benefits of interregional transmission, these <u>studies do not create an actionable "need" for approving projects</u>
- Multiple paths to establish the need for and planning of interregional transmission projects based on:
  - the value they provide to the electricity system; and
  - planning process implementation by federal and regional planning authorities
- These paths can be pursued simultaneously, identifying transmission needs through:
  - **New Interregional Tx requirements?**
  - **New Federal planning?**
  - **Improved joint RTO planning**
  - **Expanded planning by individual RTOs**



Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Proposal: Transmission Planning for the 21st Century*

Available experience points to proven planning practices that reduce total system costs and risks:

1. **Proactively plan for future generation and load** by incorporating realistic projections of the anticipated generation mix, public policy mandates, load levels, and load profiles over the lifespan of the transmission investment
2. **Account for the full range of transmission projects' benefits** and **use multi-value planning** to comprehensively identify investments that cost-effectively address all categories of needs and benefits
3. **Address uncertainties and high-stress grid conditions explicitly through scenario-based planning** 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 network portfolios** to address system needs and **cost allocation** more efficiently and less contentiously than a project-by-project approach
5. **Jointly plan inter-regionally across neighboring systems** to recognize regional interdependence, increase system resilience, and take full advantage of interregional scale economics and geographic diversification benefits

* Brattle & Grid Strategies Report: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, October 2021.

Presented By

Johannes P. Pfeifenberger

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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 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 transmission-related renewable generation 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, resource adequacy, and wholesale power market design matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, Alberta and Ontario.

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.

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Pfeifenberger, Spokas, Hagerty, Tsoukalis, A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

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Ruiz, "Transmission Topology Optimization: Application in Operations, Markets, and Planning Decision Making," May 2019.

Chang and Pfeifenberger, "Well-Planned Electric Transmission Saves Customer Costs: Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future," WIRES and The Brattle Group, 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 The Brattle Group, April 2015.

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

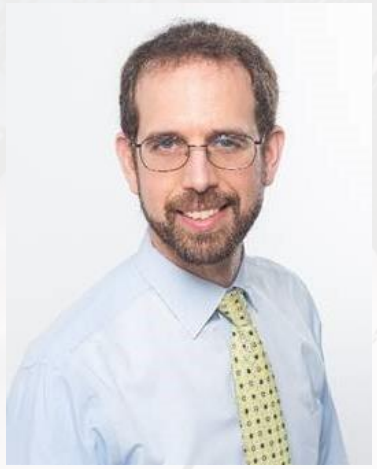
Pfeifenberger and Hou, "Seams Cost Allocation: A Flexible Framework to Support Interregional Transmission Planning," on behalf of SPP, April 2012.

Pfeifenberger, Hou, "Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada," on behalf of WIRES, May 2011.

Questions and Discussion

Study Overview

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY



Carl Mas

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Hamody Hindi

Office of Electricity

David Hurlbut

National Renewable Energy Laboratory

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ENERGY
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National Transmission Planning Study

March 15, 2022

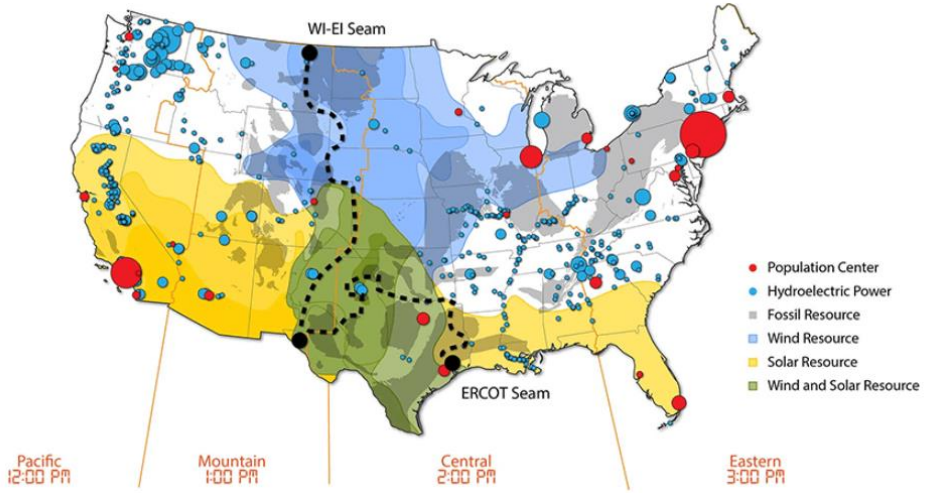
Agenda

- Introduction
  - Project team
  - Objectives
  - Desired outcomes
- Project Scope
  - Baseline analysis
  - Scenario analysis
  - Public engagement

Project team

This study is being conducted by a joint **National Renewable Energy Laboratory (NREL)** and **Pacific Northwest National Laboratory (PNNL)** project team

This study builds on past projects and expertise at NREL and PNNL with the support and direction of DOE's Office of Electricity



U.S. DEPARTMENT OF ENERGY

Office of Electricity

North American Energy Resilience Model

U.S. DEPARTMENT OF ENERGY | Office of Electricity

Objectives of the study

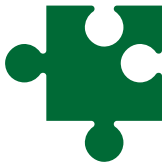
1. Identify **interregional and national strategies** to accelerate cost-effective **decarbonization** while maintaining system reliability

2. Inform regional and interregional transmission planning processes, particularly by **engaging stakeholders** in dialogue

3. Identify **viable and efficient** transmission options that will provide broad-scale benefits to electric customers

Desired outcomes of the study

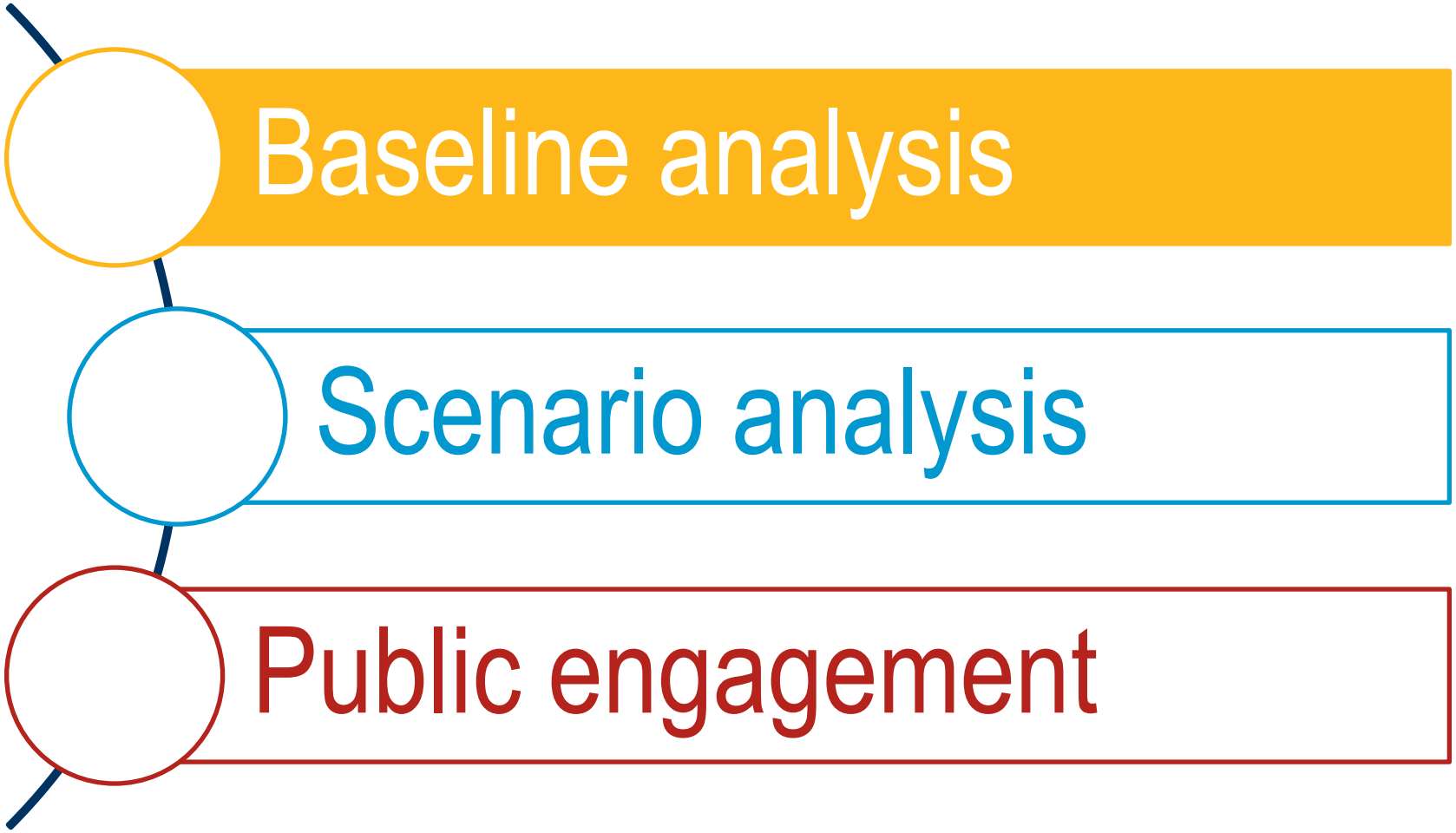
Results help **prioritize future DOE funding** for transmission infrastructure support



Results help **fill existing gaps** within interregional transmission planning

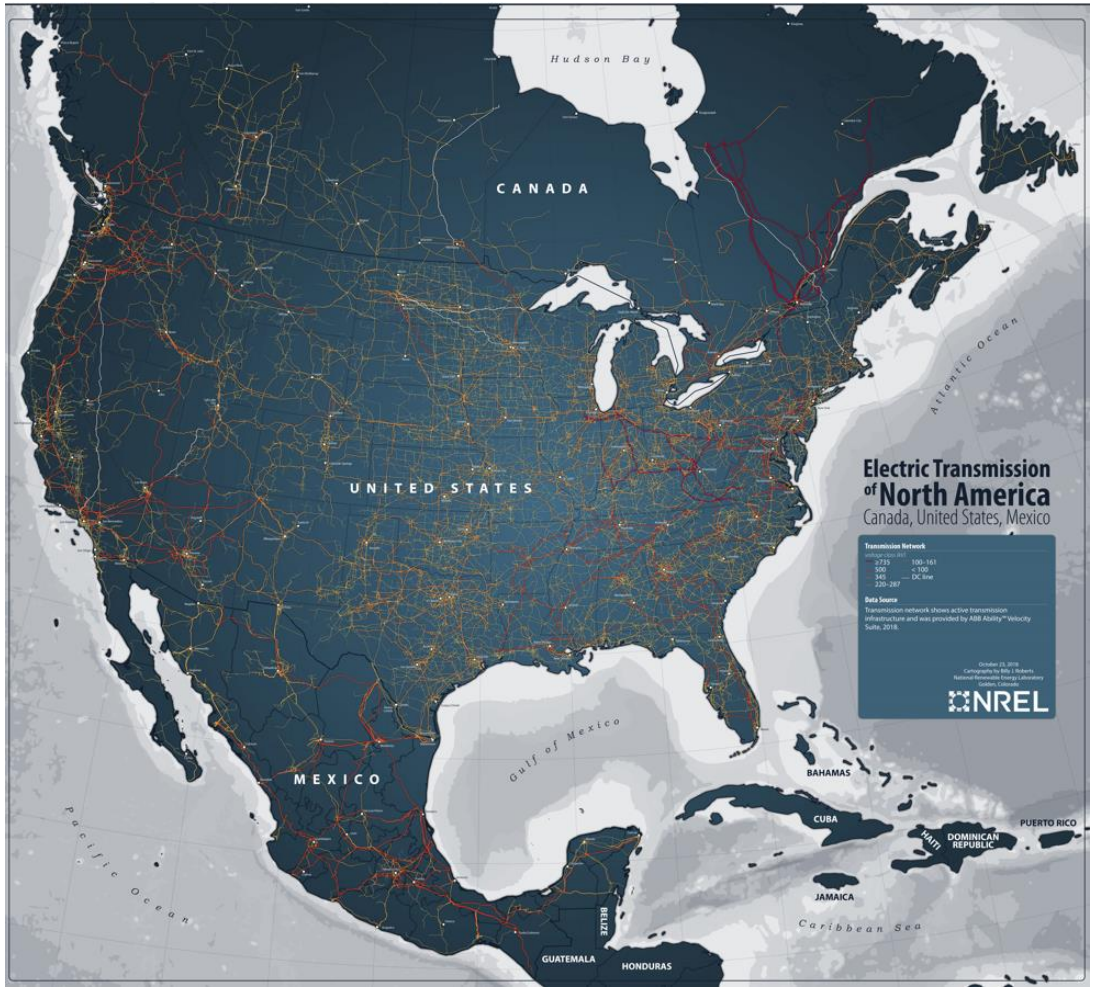
Study provides a framework for stakeholders to discuss **desired grid outcomes** and **address barriers** to achieving them

National Transmission Planning Study Scope


Baseline analysis
Scenario analysis
Public engagement

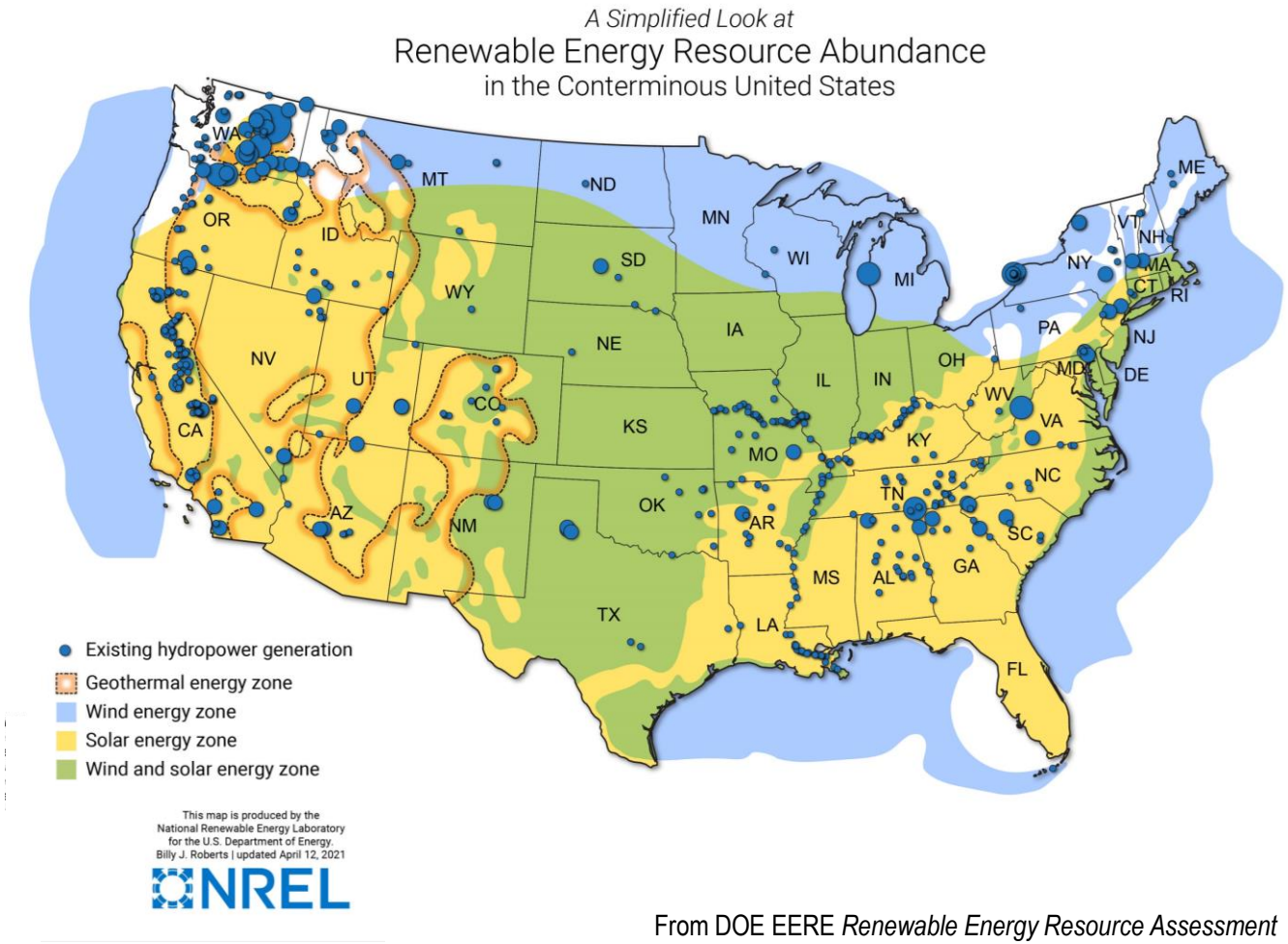
Baseline Analysis: Key Tasks

- Develop database of large, high-probability **transmission projects** likely to be in place by 2030
- Develop a database of power **generation projects** likely to be in operation in 2030
- From the above develop a transmission and power generation **nodal base case**
- Use the nodal base case to **conduct power flow and production cost modeling** for the grid in 2030
- **Answer the question**: How close does the currently-planned 2030 system get to meeting the Administration's 2035 decarbonization goal?



Baseline Analysis: Incorporating High Renewables

- Start from Baseline 2030 system
- Interconnect additional renewable generation to fully utilize planned 2030 transmission
- **Answer the question**: How close does the currently-planned 2030 system + high renewables get to meeting the country's 2035 decarbonization goal?



From DOE EERE *Renewable Energy Resource Assessment Information for the United States* (March 2022)


Baseline analysis
Scenario analysis
Public engagement

Scenario Analysis: Key Tasks

- Define different **scenarios or storylines** to explore in capacity expansion modeling to identify potential future generation resources and transmission expansion options (more details on next slide)
- Conduct **capacity expansion modeling**
- Independently, identify potential **interregional renewable energy zones**
- Conduct **production cost modeling**
- Conduct **AC power flow** and **dynamic reliability** analysis
- Conduct **economic analysis**
- Conduct **stress case** and **resource adequacy** analysis
- Identify a **portfolio of potential transmission options**

Scenario Analysis: Drivers and Characteristics

Transmission Drivers

Topology
- Intra-Balancing Area
- Interconnection-Wide Expansion
- Macrogrid Overlay

Technology & Cost
- Existing Technology & Costs
- High Costs
- Voltage Source Converters
- Non-wires Alternatives (e.g., FACTS, DLR, etc.)

Demand Drivers

Electrification
- High
- Medium
- Low

Distributed energy resources
- High
- Medium
- Low

Generation Drivers

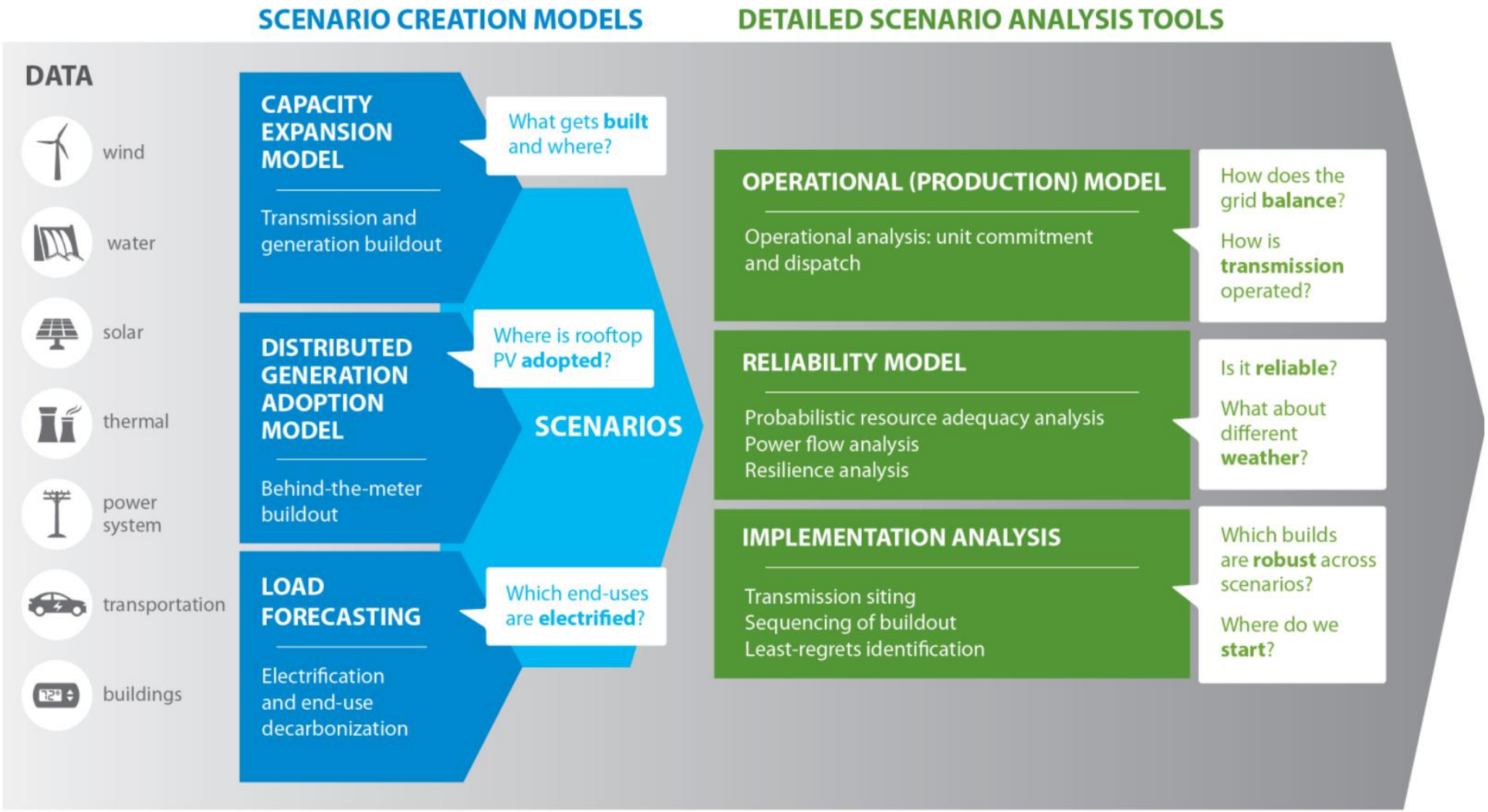
Renewable siting
- Open
- Reference
- Constrained

RE & Storage Costs
- High
- Medium
- Low

Thermal fleet
- Nuclear fleet extension
- Clean firm capacity
- Carbon capture and sequestration

We welcome feedback on which of these are the most important to consider.

Scenario Analysis: Study Plan

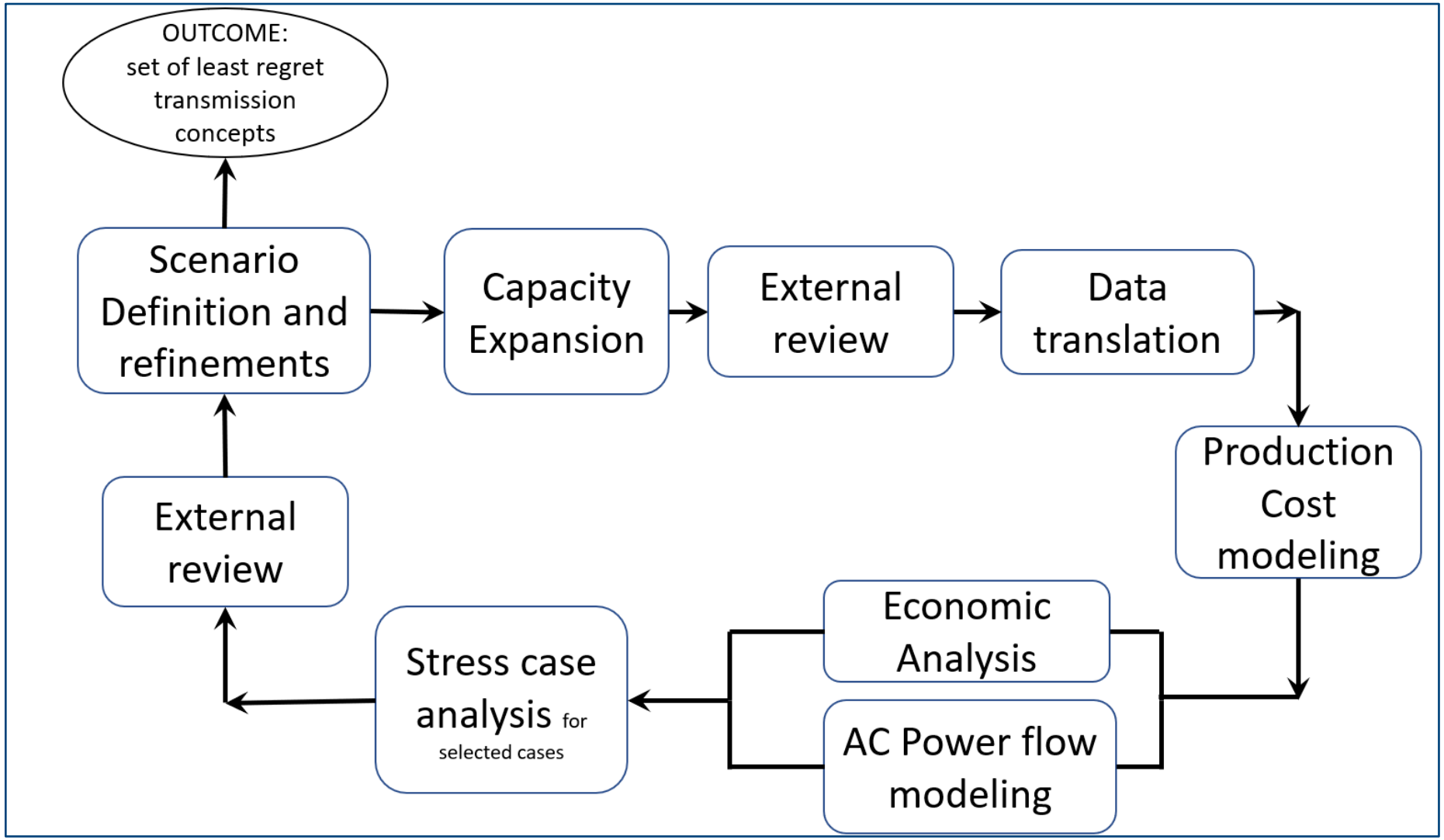


Scenario Analysis: Iterative Modeling and Review

Scenarios will be down-selected throughout modeling process.

Will start with several dozen scenarios and end with only a few.

Top-down and bottom-up approach throughout



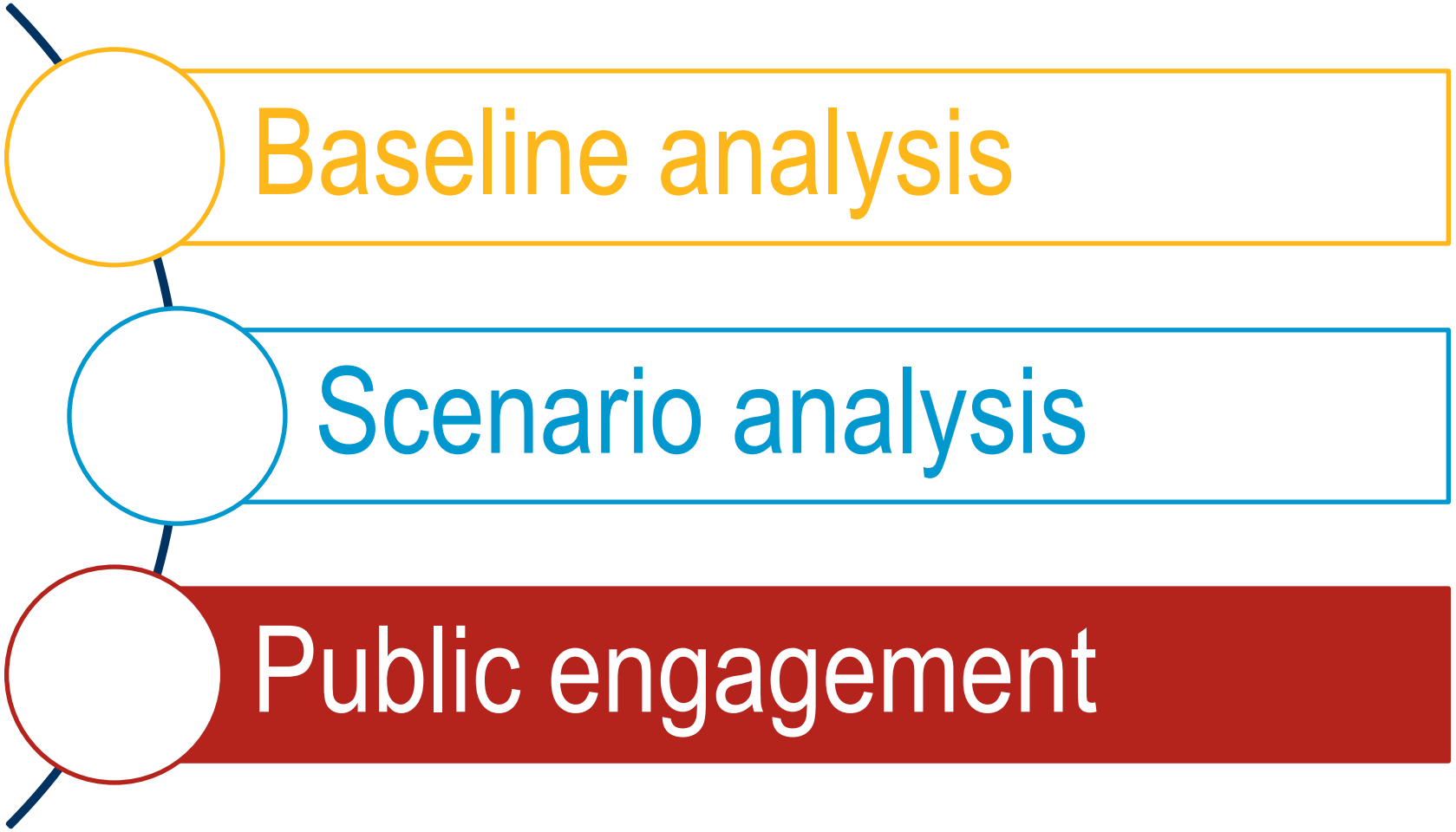
Scenario Analysis: What it is doing and is not

What the study will do

- Link several long-term and short-term power system models to test a number of transmission buildout scenarios
- Inform existing planning processes
- Test transmission options that lie outside current planning
- Provide a wide range of economic, reliability, and resilience indicators for each transmission scenario

What the study will not do

- Replace existing regional and utility planning processes
- Site individual transmission line routes
- Address the detailed environmental impacts of potential future transmission lines
- Provide results that are as granular as planning done by utilities
- Develop detailed plans of service


Baseline analysis
Scenario analysis
Public engagement

Public Engagement: Four Aspects

Public Workshops and Input

- Introduce project and provide updates
- Share interim and final results
- Provide opportunities for public feedback via website

Existing Convenor Groups

- Validate data and input assumptions
- Discuss consistency with groups' existing efforts
- Share project updates and interim results

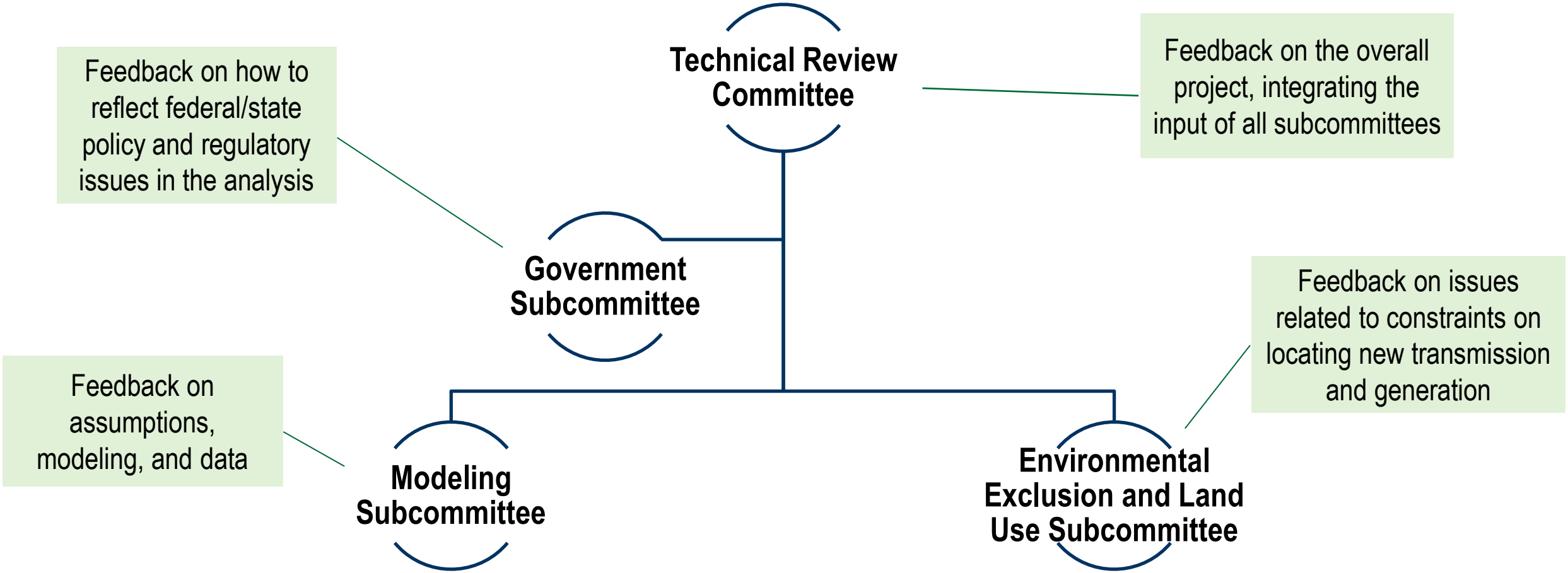
Technical Review Committee

- Provide project input
- Suggest project course corrections
- Review interim results

Tribal Outreach

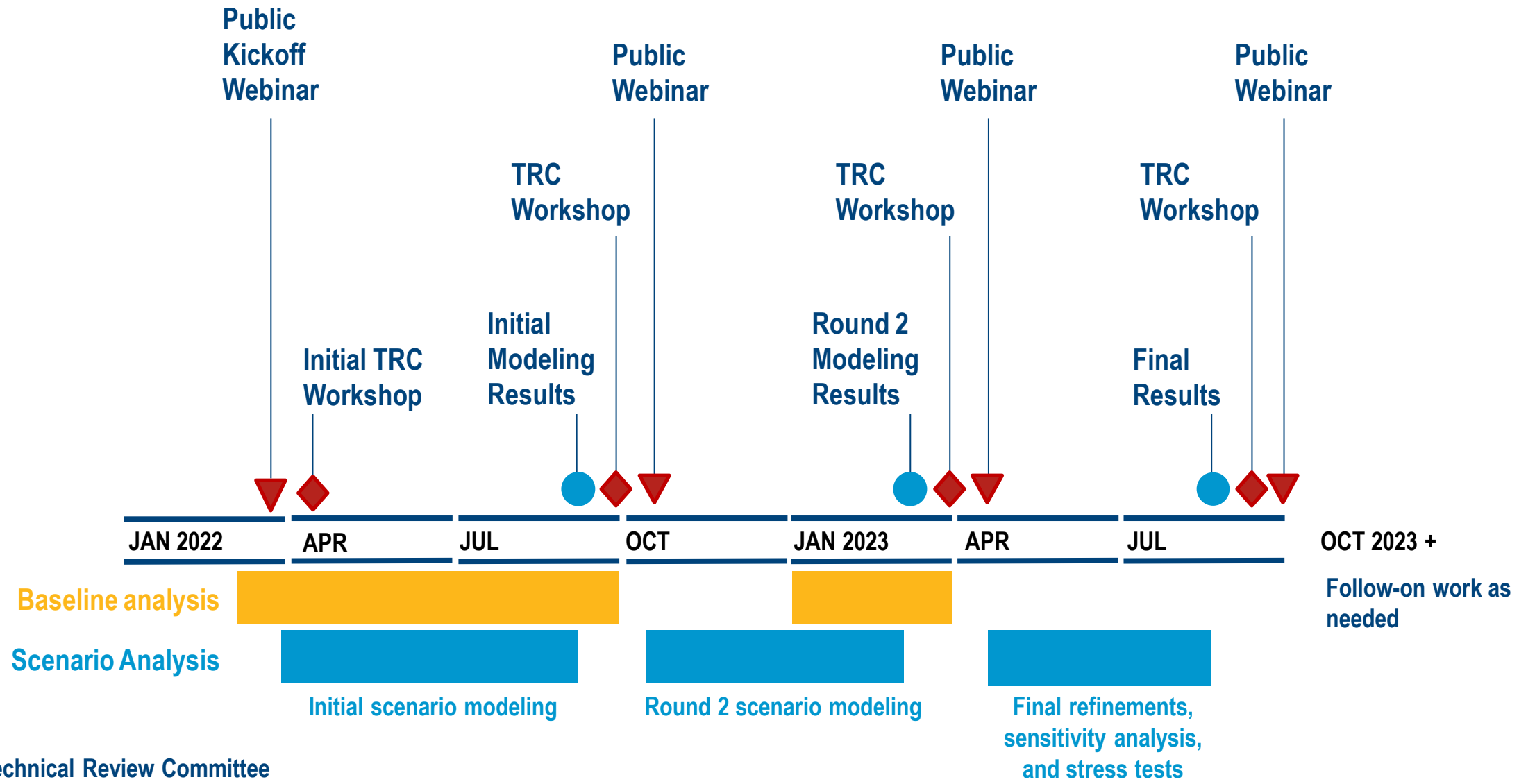
- Initiate broad outreach to all Tribes
- Invite statements of interest
- Incorporate Tribal input into analysis

Public Engagement: Technical Review Committee



Members will be invited based on knowledge and expertise, interest, sectoral and geographic diversity, participation in previous planning efforts, and other criteria

Public Engagement: Preliminary Timeline

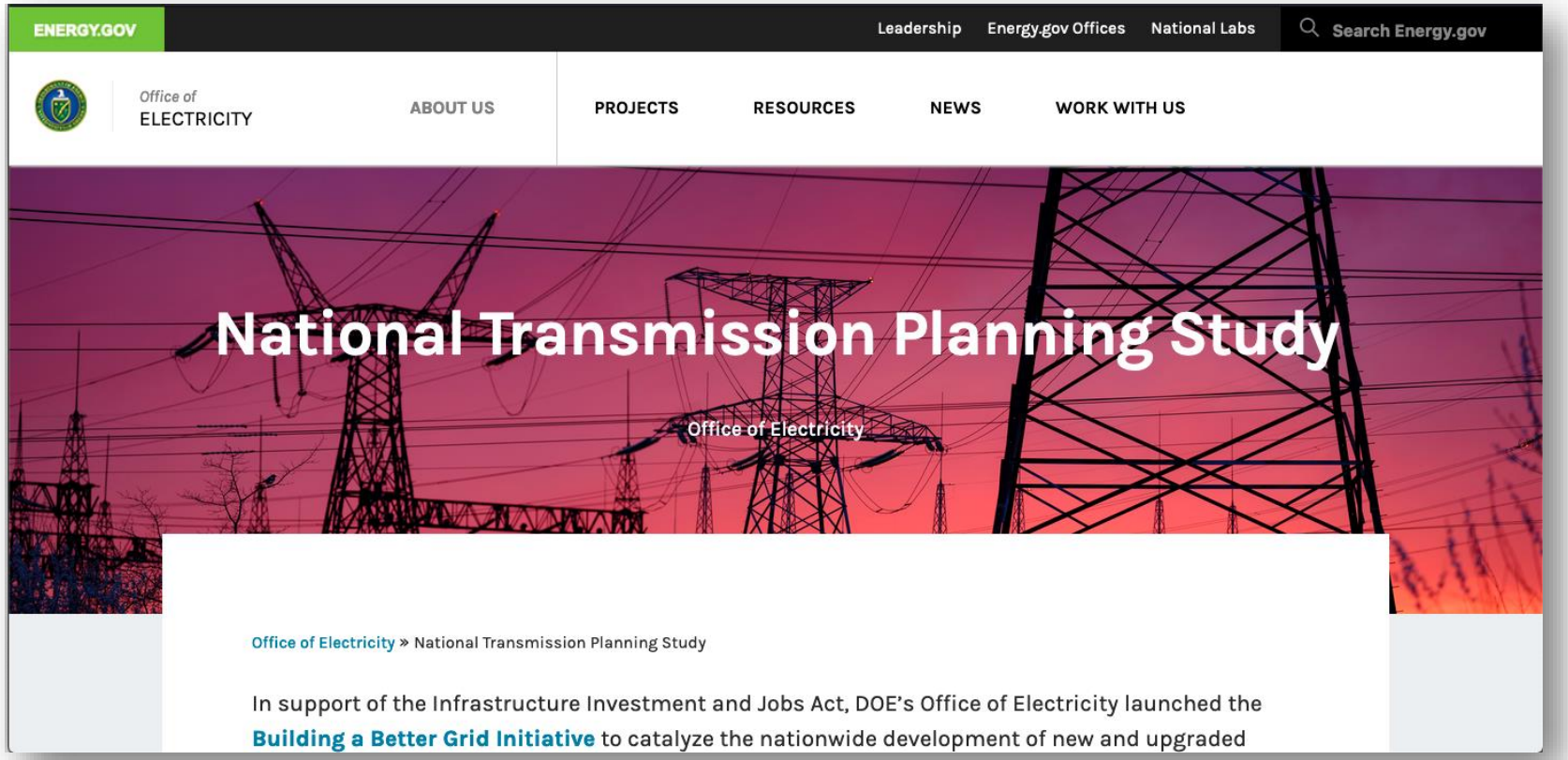


TRC = Technical Review Committee

How to get updates and provide comments

https://www.energy.gov/oe/national-transmission-planning-study

- Overview of NTP Study goals and objectives
- Project news and milestone results
- Webinar presentations (including this one)
- NTP Study mailing list
- TRC meeting schedules and presentation materials
- **Public comment form**



Q&A and Discussion

Next steps

- **Participants provide comments** through the comment form on the website
- Interested parties **sign up for email** updates through the NTP Study website
- Lab team will continue conducting the **baseline and scenario analysis**
- Lab team will select **Technical Review Committee (TRC) members**
- **Initial TRC meeting** - April
  - Emails will be sent to the distribution list about this and all TRC meetings
- **Next public webinar** will be in Fall 2022 to share interim results

Thank You!

Office of Electricity
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