Well-Planned Electric Transmission Saves Customer Costs:

Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future

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THE Brattle GROUP

Brattle-WIRES Reports on Transmission Planning

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PREPARED FOR

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THE Brattle GROUP

http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Report_TransmissionPlanning_June2016.pdf

Toward More Effective Transmission Planning:

Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid

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http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Rpt_TransPlanning_042315.pdf

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April 2015

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http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Rpt%20Benefits%20Transmission%20July%202013.pdf

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

July 2013

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Agenda

CPP and Other Drivers for Transmission Investment Needs

The Urgent Need for Improved Transmission Planning

Review of Industry Studies: Well-Planned Transmission Reduces Overall Customer Costs

Planning Under Uncertainty: Using Scenario-Based Planning that Considers the Costs and Risks of Inadequate Infrastructure

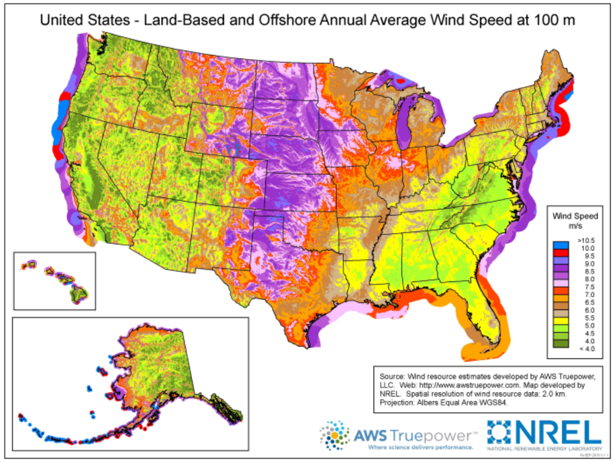
Conclusions

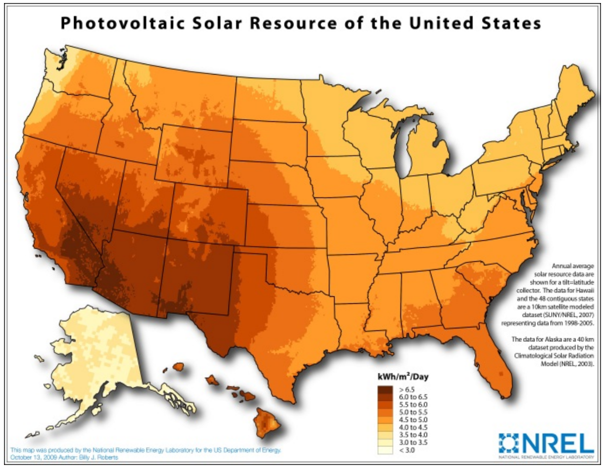
Main Drivers of Transmission Needs

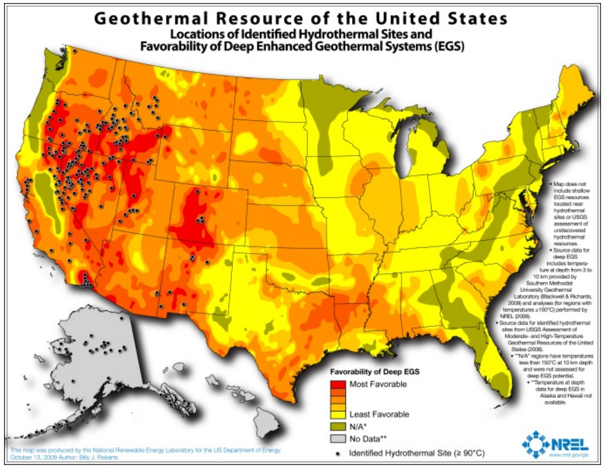
- **Serve growing load**
- **Load diversity:** reduce overall reserve margins and generating capacity needed to ensure resource adequacy
- **Congestion relief/production cost savings:** reduce congestion and increase access to lowest-cost generation to reduce fuel costs and wholesale energy prices
- **Access to low-cost renewables:** access to regions with low-cost wind, solar, geothermal, and hydro resources
- **Renewable energy and fuel diversity:** diversify short and long-term variability of wind, solar, and hydro generation; diversify fuel mix and cost variances within and across uncertain futures
- **Increasingly stringent environmental regulations:** increase regional "boundaries" to reduce the cost of environmental compliance in a range of possible futures

Renewable Resource Potential

- Potential for and quality of renewable energy resources vary by region
- Lowest-cost onshore wind resources are on the edge with Eastern Interconnection and Texas. These resources have a 10-15% capacity factor advantage relative to the rest of the country, which translates to more than $20/MWh reduction in the cost of wind generation
- Southwest has a tremendous amount of solar resources
- Some western states have the highest potential for geothermal
- There is also significant opportunity to increase import from Canadian hydropower







Source: NREL

How will CPP Drive Transmission Development?

- Uncertainties remain about how CPP will be implemented:
  - Stay/Timing
  - How emissions will be reduced physically: renewables, EE, coal-to-gas switching
  - Focus on in-state, regional, or national solutions (state tend to focus internally first)
- Coal retirements or coal-to-gas switching likely will be only a modest driver for regional transmission needs and even less of a driver for interregional need
- Most significant driver for transmission will be the **extent to which low-cost renewable resources are relied upon** for emission reduction
  - Compliance approach chosen, gas prices, carbon costs/prices, and availability and magnitude of tax credits will have significant impact on the economics of renewables
- Transmission continues to face the "chicken-or-egg" challenge
  - Facilitating low-cost renewable development will require new transmission
  - But without the renewable resource development occurring, existing transmission planning processes will not identify transmission needs
- **To overcome this challenge, planning must anticipate future uncertainties and planners must inform regulators and policy makers**

Industry Trends Beyond CPP

Improved transmission planning is needed in light of industry trends, irrespective of CPP:

- Federal and state policies provide incentives for renewable energy resources
- Significant cost reduction in solar and wind generation and innovative project financing, yielding PPA prices below $25/MWh for wind generation and below $40/MWh for solar generation
- Low natural gas prices place downward pressure on coal and nuclear plants
- Increased stringency in other environmental regulations of air emissions, water usage, waste disposal, and land use for all power plants
- Reduced growth in electricity consumption
- Increased customer preferences for energy conservation and electricity from “green” resources
- Technological advances that allow customers and electric utilities to better monitor and control electricity usage
- Increasing electrification of transportation

Broader Picture: Transmission's Role in Addressing Major Energy Policy Challenges

How does a region or the country decarbonize?

- Actions needed now to meet aggressive targets for the next 2 decades
- Ask: "How do we integrate a "diverse" mix of supply and demand-side resources? "

Transmission Provides Answers to a Significant Portion of the Questions

- To reliably gather and deliver new clean energy resources, transmission will be needed.
- Transmission provides significant additional value:
  - Opens and expands future supply and demand-side choices
  - Mitigates the impact of extreme weather events
  - Reduces cost of generation
  - Reduces cost of integrating renewable energy
  - Maintain reliability and sustainability

Regions and states need to work together to plan regional and inter-regional infrastructure

Key Shortfalls in Traditional Transmission Planning

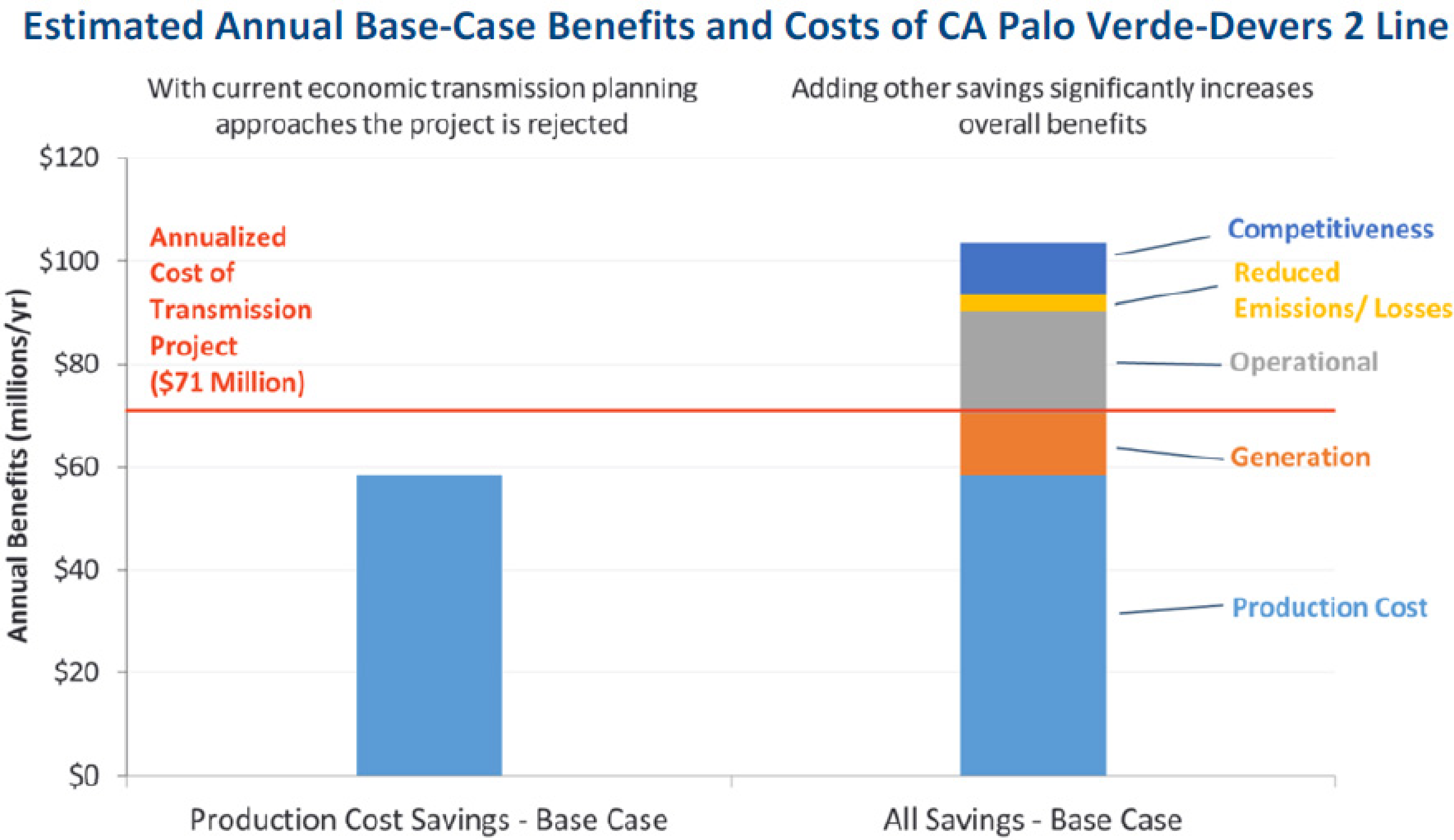
Three key barriers to identifying and developing the most valuable transmission infrastructure investments:

- Planners and policy makers **do not consider the full range of benefits** that transmission investments can provide and thus understate the expected value of such projects
- Planners and policy makers **do not account for the high costs and risks** of an insufficiently robust and insufficiently flexible transmission infrastructure on electricity consumers and the risk-mitigation value of transmission investments to reduce costs under potential future stresses
- **Interregional planning processes are ineffective** and are generally unable to identify valuable transmission investments that would benefit two or more regions
- Additional challenges related to regional cost recovery and state-by-state permitting processes

"Checklist" of Transmission Benefits

Benefit Category	**Transmission Benefit** (see 2013 WIRES paper)
Traditional Production Cost Savings	Production cost savings as currently estimated in most planning processes
1. Additional Production Cost Savings	a. Impact of generation outages and A/S unit designations
	b. Reduced transmission energy losses
	c. Reduced congestion due to transmission outages
	d. Mitigation of extreme events and system contingencies
	e. Mitigation of weather and load uncertainty
	f. Reduced cost due to imperfect foresight of real-time system conditions
	g. Reduced cost of cycling power plants
	h. Reduced amounts and costs of operating reserves and other ancillary services
	i. Mitigation of reliability-must-run (RMR) conditions
	j. More realistic "Day 1" market representation
2. Reliability and Resource Adequacy Benefits	a. Avoided/deferred reliability projects
	b. Reduced loss of load probability or c. reduced planning reserve margin
3. Generation Capacity Cost Savings	a. Capacity cost benefits from reduced peak energy losses
	b. Deferred generation capacity investments
	d. Access to lower-cost generation resources
4. Market Benefits	a. Increased competition
	b. Increased market liquidity
5. Environmental Benefits	a. Reduced emissions of air pollutants
	b. Improved utilization of transmission corridors
6. Public Policy Benefits	Reduced cost of meeting public policy goals
7. Employment and Economic Stimulus Benefits	Increased employment and economic activity; Increased tax revenues
8. Other Project-Specific Benefits	Examples: storm hardening, fuel diversity, flexibility, reducing the cost of future transmission needs, wheeling revenues, HVDC operational benefits

Considering All Transmission Benefits is Important



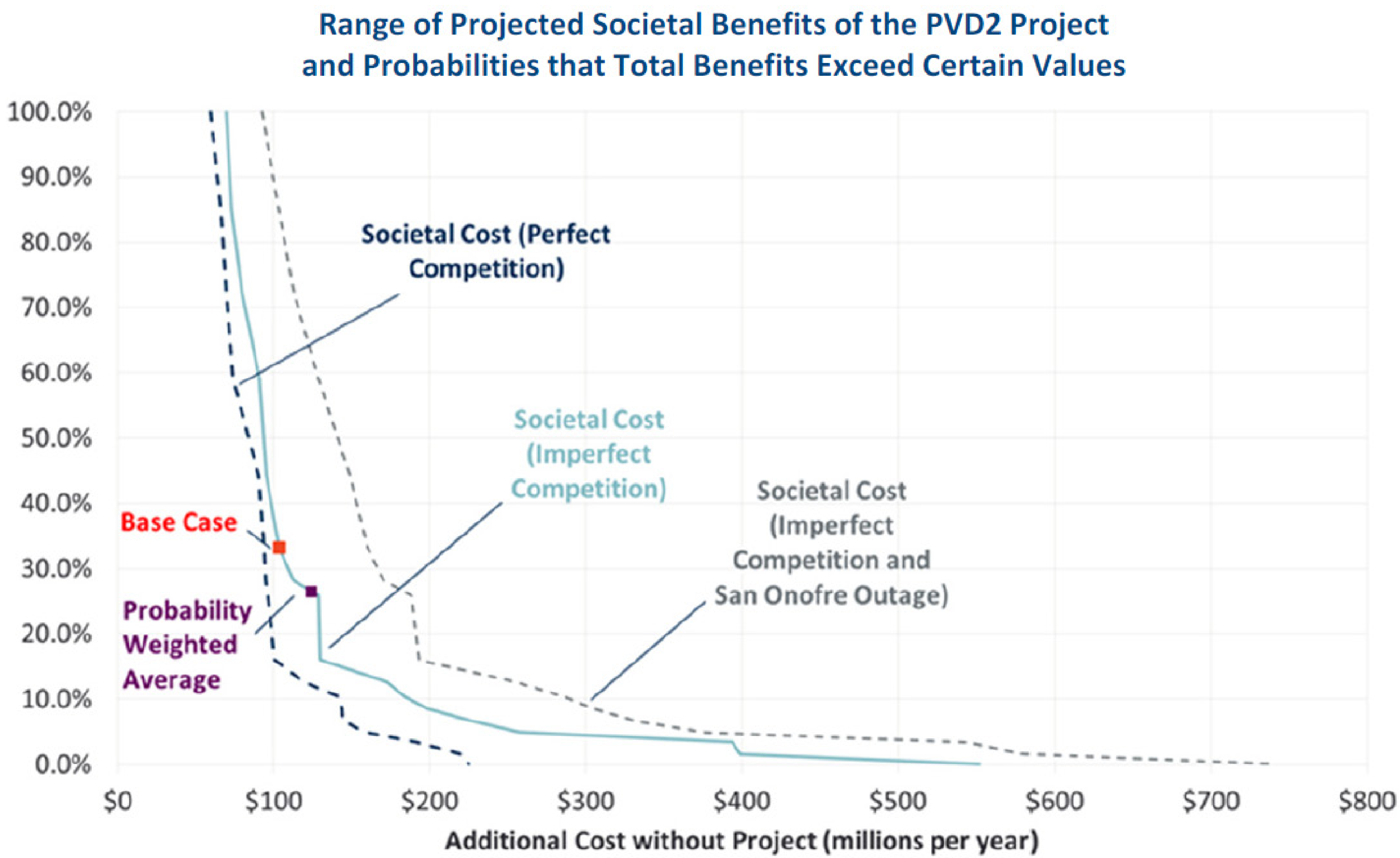
Inadequate Transmission Imposes High Risks

Most transmission planning efforts do not adequately account for short- and long-term risks and uncertainties affecting power markets

- Economic transmission planning generally evaluates only "normal" system conditions and typically ignores the high cost of short-term **challenges and extreme market conditions** triggered by weather, outages, fuel supply disruption, unexpected load growth
- Planning does not adequately consider the full range of long-term scenarios and does not capture the extent to which a less robust and flexible transmission infrastructure will **foreclose lowest-cost options in the long-term**

Costs of inadequate infrastructure typically are not quantified but, in light of considerable uncertainties, can be much greater than the costs of the transmission investments

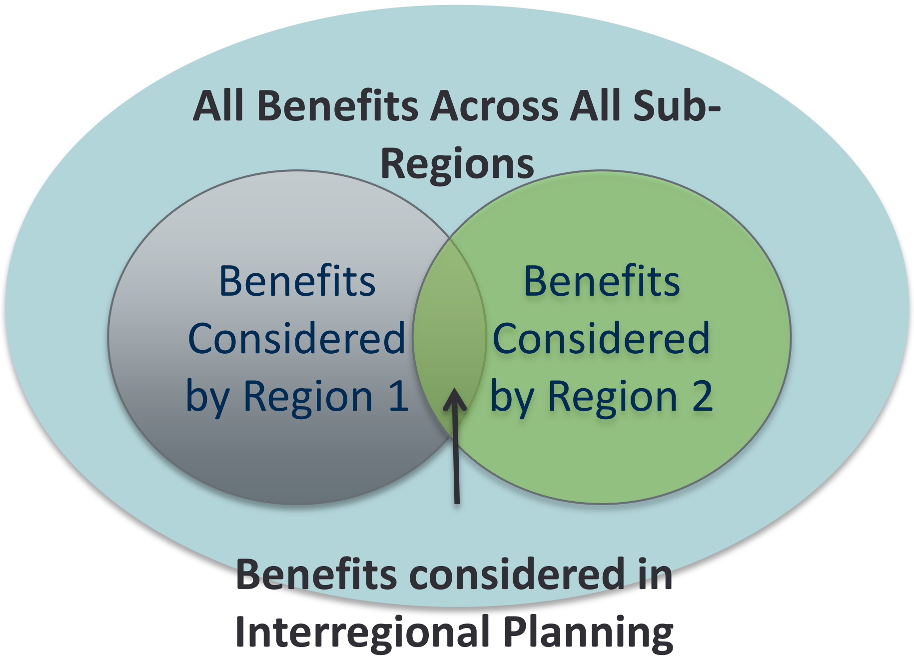
Transmission Can Mitigate Very High-Cost Outcomes, Particularly if Future is Uncertain



Ineffective Inter-Regional Transmission Planning

Divergent criteria result in "least-common-denominator" planning approaches create significant barriers for transmission between regions

- Experience in the East already shows that very few (if any) interregional projects will be found to be cost effective under this approach
- Multiple threshold tests create additional hurdles



Planning processes need to be improved to avoid this "least common denominator" outcome by evaluating interregional projects based on their combined benefits across all regions

Ineffective "Compartmentalized" Planning

Experience from the Eastern RTOs shows that most planning processes compartmentalize needs into "reliability," "market efficiency," "public policy," and "multi-value" projects – which in turn fails to identify valuable projects.

Projects Considered in MISO-PJM Planning:
(as Ordered by FERC)

Project Type in RTO-1 \ Project Type in RTO-2	Reliability	Market Efficiency	Public Policy	Multi-Value
Reliability	Yes	no	no	no
Market Efficiency	no	Yes	no	no
Public Policy	no	no	Yes	no
Multi Value	no	no	no	no

- Compartmentalizing creates additional barriers at the interregional level by limiting projects to be of the same type in neighboring regions (see MISO-PJM example).
- It eliminates many projects from consideration simply because they don't fit into the existing planning "buckets."

The Urgent Need for Better Planning Processes

Efforts to improve planning processes need to start immediately to fully realize the potential future savings for at least three reasons:

1. Transmission projects **require at least 5–10 years** to plan, develop, and construct; as a result, planning would have to start now to more cost-effectively meet the challenges of changing market fundamentals and the nation's public policy goals in the 2020–2030 timeframe;
2. A continued reliance on **traditional transmission planning** that is primarily focused on reliability needs **will lead to piecemeal solutions** instead of developing integrated and flexible transmission solutions that enable the system to meet public policy goals more cost effectively; and
3. We are in the midst of an investment cycle to **upgrade or replace aging existing transmission infrastructure**, mostly constructed in the 1960s and 70s; this provides unique opportunities to create a more modern and robust electricity grid at lower incremental costs and with more efficient use of existing rights-of-way for transmission.

The Need for More Effective Grid Planning

If not addressed, barriers to effective regional and interregional transmission planning will lead to:

- **Lost opportunities to identify and select infrastructure solutions** that are lower-cost or/and higher-value in the long term than the (mostly reliability-driven) projects proposed by planners.
- An **insufficiently robust and flexible grid that exposes customers** and other market participants to higher costs and higher risk of price spikes.
- Poorly planned transmission **forecloses lower-cost options** to address environmental policy goal and industry challenges at lower costs

Higher cost of delivered electricity, higher customer costs to meet long-term public policy goals

Industry Studies Show Well-Planned Transmission Investments Reduce Total Costs

U.S. industry studies consistently show that well-planned transmission investment can significantly reduce overall customer costs:

- **SPP:** $3.4 billion on transmission projects previously planned are expected to reduce customer costs by $12 billion at a benefit to cost ratio of 3.5-to-1 (retrospective evaluation)
- **MISO MVP:** Previously planned multi-value projects to integrate 40 million MWh of renewables and improve reliability provide benefits that exceed costs by factor of 2.6-3.1
- **Brattle:** Providing access to areas with lower-cost renewable generation that will meet RPS and CPP needs through 2030 has the potential to reduce the combined generation and transmission investment needs by $30-70 billion
- **Eastern Interconnection States Planning Council:** Multi-stage anticipatory planning can reduce total generation costs by $150 billion, while increasing interregional transmission investments by $60 billion, with an overall savings of $90 billion system-wide
- **Eastern Interconnection Planning Collaborative:** Combination of interregional environmental policy compliance and interregional transmission may offer net savings of up to $100 billion in a future with stringent environmental policy goals
- **University of Colorado/National Oceanic and Atmospheric Administration:** Building more robust transmission grid would enable reducing U.S. carbon emissions from electricity sector by 80%, saving consumers $47 billion/year at benefit-to-cost ratio of almost 3-to-1.

Industry Studies Show Well-Planned Transmission Investments Reduce Total Costs

European studies come to the same conclusions:

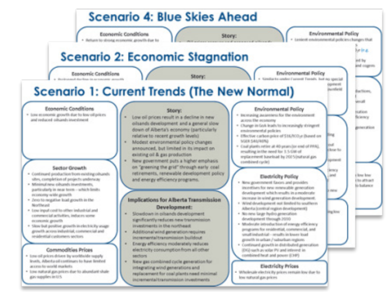
- **European E-Highway 2050 Study:** Interregional transmission investments significantly reduce the cost of a low-carbon electricity sector by facilitating the integration and diversification of lower-cost renewable resources region-wide
- **Integration of Renewable Energy in Europe:**
  - Most cost-effective path to achieving Europe's overall renewable energy policy objectives requires a substantial expansion of its transmission networks; delay in investments increases the overall system-wide costs and price volatility.
  - Choice between centralized, utility-scale generation and distributed generation does not have a direct impact on transmission needs
- **Germany:** three new north-south transmission lines needed to reduce the cost of a clean energy future despite substantial reliance on distributed generation
- **Transformation of Europe's Power System Until 2050:**
  - McKinsey study found that the most cost-effective way to reach 40–45% renewables by 2050 would require a doubling of existing region-wide transmission capabilities by 2020 and an almost fourfold increase in transmission capabilities by 2050.
  - Local approach would be 30–35% more expensive Europe-wide interregional coordination.

Scenario-Based Transmission Planning

1. Identifying Future Trends, Drivers and Uncertainties

– Industry experts from within and outside of the power industry develop views on a range of future trends, drivers, and uncertainties

2. Developing Future Scenarios



– Develop future scenarios based on the trends, drivers and uncertainties identified
– Ensure that each scenario is internally consistent and captures a sufficiently wide range of future states of the world

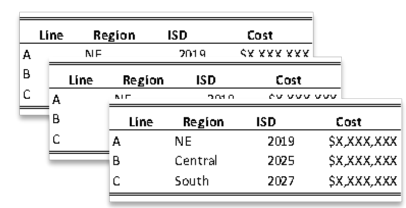
3. Transforming Future Scenarios into Planning Assumptions

– Translate the qualitative descriptions of the future scenarios to specific assumptions that are used in transmission planning

Key Driver	Current	Stagnation	Blue Skies
Economic Conditions	Base	Low	High
Sector Growth	Base	Low	High
Commodity Prices	Base	Low	High
Environmental Policy	Base	Low	Low
Electricity Policy	Base	Base	Low

4. Simulate the Grid under each Future Scenario

– Develop power flows for each future scenario
– Compare the size and timing transmission needs across scenarios



Line	Region	ISD	Cost
A	NE	2019	$X,XXX,XXX
B	Central	2025	$X,XXX,XXX
C	South	2027	$X,XXX,XXX

Example: ERCOT Long-Term System Assessment

http://www.brattle.com/news-and-knowledge/news/brattle-consultants-assist-ercot-in-scenario-planning-and-improving-its-long-term-transmission-planning-process

Table 3.1: 2014 LTSA Key Drivers Developed by ERCOT Stakeholders

Key Drivers	Description
Economic Conditions	U.S. and Texas economy; regional and state-wide population, oil & gas, and industrial growth; Liquefied Natural Gas (LNG) export terminals; urban/suburban shifts; financial market conditions; and business
Environmental Regulations and Energy Policy	Environn ozone, N 316(b)), renewab mandate
Alternative Generation Resources	Capital c improver capacity (DG) cos
Natural Gas and Oil Prices	Gas price LNG exp prices ar spread c affect dr
Transmission Regulation and Policies	New pol neighbor
Generation Resource Adequacy Standards	Economi flexible r
End-Use/New Markets	End-use demand- increase
Weather and Water Conditions	May affe technolo extreme

Table 3.2: 2014 LTSA Scenarios Developed by Stakeholders

Candidate Scenarios	Description
Current Trends	Trajectory of what we know today (e.g., LNG export terminals and West Texas growth, prolonged high oil prices)
Global Recession	Significant reduction in economic activities in the U.S. and abroad
High Economic Growth	Significant population and economic growth from all sectors of the economy (affecting residential, commercial, and industrial load)
High Efficiency/High DG/Changing Load Shape	Reduced *net* demand growth due to increase in distributed solar, cogeneration and higher building and efficiency standards
High Natural Gas Prices	High domestic gas prices
Stringent Environmental Regulation/Solar Mandate	On top of current regulations, the Environmental Protection Agency (EPA) also regulates GHG emissions. Federal or higher Texas renewable standards. More stringent water regulations. Texas legislative mandate on utility-scale and distributed solar development.
High LNG Exports	Significant additional construction of liquefied natural gas (LNG) terminals (beyond Current Trends)
High System Resiliency	Severe climate and system events leading to more stringent reliability and system planning standards
Water Stress	Low water availability
Low Global Oil Prices	Sustained low oil prices

Interpretation and Uses of the Scenario-Based Transmission Planning

- Future scenarios are used to **evaluate the potential future transmission** needs (including location, size and timing)
  - A scenario **does not represent a deterministic future** that *will* occur. Instead, together the **scenarios cover the range of plausible futures**
- Some planners are inclined to assign "probabilities" to each future scenario, inevitably assigning "Current Trends" the highest probability because it is developed **with "known and knowable facts" today**
  - Best to not assign probabilities, instead, **carry all scenarios to market simulations** and evaluate the transmission projects needed under all scenarios
- Deploying transmission projects that **create future options** requires a multi-stage planning process that considers future scenarios and uncertainties as they are resolved
- Assess if certain projects:

  (1) Are needed in multiple/most scenarios;

  (2) Mitigate the risk of very high cost outcomes;

  (3) Are better long-term solutions than other projects that only address the immediate needs.
- Scenario-based transmission planning can also help **evaluate the types of public policies** that transmission can support

Conclusions

- A **more flexible transmission grid will be a critical component** for more cost-effectively serving electricity customers in a rapidly changing industry
- Because the development of transmission takes at least five to ten years, the industry **cannot wait to start planning** for these needs until the uncertainties resolve themselves.
  - Taking a "wait-and-see" approach would foreclose the development of lower-cost options for meeting the challenges that will invariably be faced by the industry over the next decade
  - To capture the low-cost opportunities, states and regions will need to collaborate more actively in compliance and transmission planning
- To address future uncertainties and policy challenges more proactively, policymakers and regulators **must engage <u>now</u> in evaluating the critical role** that transmission investments can in reducing customer cost and risks
  - Requires a careful assessment of how transmission can reduce the cost of meeting industry trends and regulations
  - Even without the requirements set by EPA's CPP, building a robust grid will ensure reliability while facilitate integration of low-cost renewable resources

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Note:

The views expressed in this presentation are strictly those of the presenter and do not necessarily state or reflect the views of *The Brattle Group, Inc*.

Ms. Judy Chang is an energy economist and policy expert with a background in electrical engineering and 20 years of experience in advising energy companies and project developers with regulatory and financial issues. Ms. Chang has submitted expert testimonies to the U.S. Federal Energy Regulatory Commission, U.S. state and Canadian provincial regulatory authorities on topics related to transmission access, power market designs and associated contract issues. She also has authored numerous reports and articles detailing the economic issues associated with system planning, including comparing the costs and benefits of transmission. In addition, she assists clients in comprehensive organizational strategic planning, asset valuation, finance, and regulatory policies.

Ms. Chang has presented at a variety of industry conferences and has advised international and multilateral agencies on the valuation of renewable energy investments. She holds a BSc. In Electrical Engineering from University of California, Davis, and Masters in Public Policy from Harvard Kennedy School, is a member of the Board of Directors of The Brattle Group, and the founding Director of New England Women in Energy and the Environment.

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Johannes (Hannes) Pfeifenberger is an economist with a background in power engineering and over 20 years of experience in the areas of public utility economics and finance. He has published widely, assisted clients and stakeholder groups in the formulation of business and regulatory strategy, and submitted expert testimony to the U.S. Congress, courts, state and federal regulatory agencies, and in arbitration proceedings.

Hannes has extensive experience in the economic analyses of wholesale power markets and transmission systems. His recent experience includes reviews of RTO capacity market and resource adequacy designs, testimony in contract disputes, and the analysis of transmission benefits, cost allocation, and rate design. He has performed market assessments, market design reviews, asset valuations, and cost-benefit studies for investor-owned utilities, independent system operators, transmission companies, regulatory agencies, public power companies, and generators across North America.

Hannes received an M.A. in Economics and Finance from Brandeis University and an M.S. in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

Additional Reading

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