

Dynamics and Opportunities in Transmission Development

PRESENTED TO:



PRESENTED BY

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DECEMBER 2, 2014

THE **Brattle** GROUP

Purpose and Introduction

This presentation provides an overview of:

- Recent trends in U.S. transmission investments
- Impact of coal plant retirements, renewable generation development, and the need to replace aging transmission infrastructure
- Other drivers of transmission needs
- Estimates of likely transmission investments over next decade

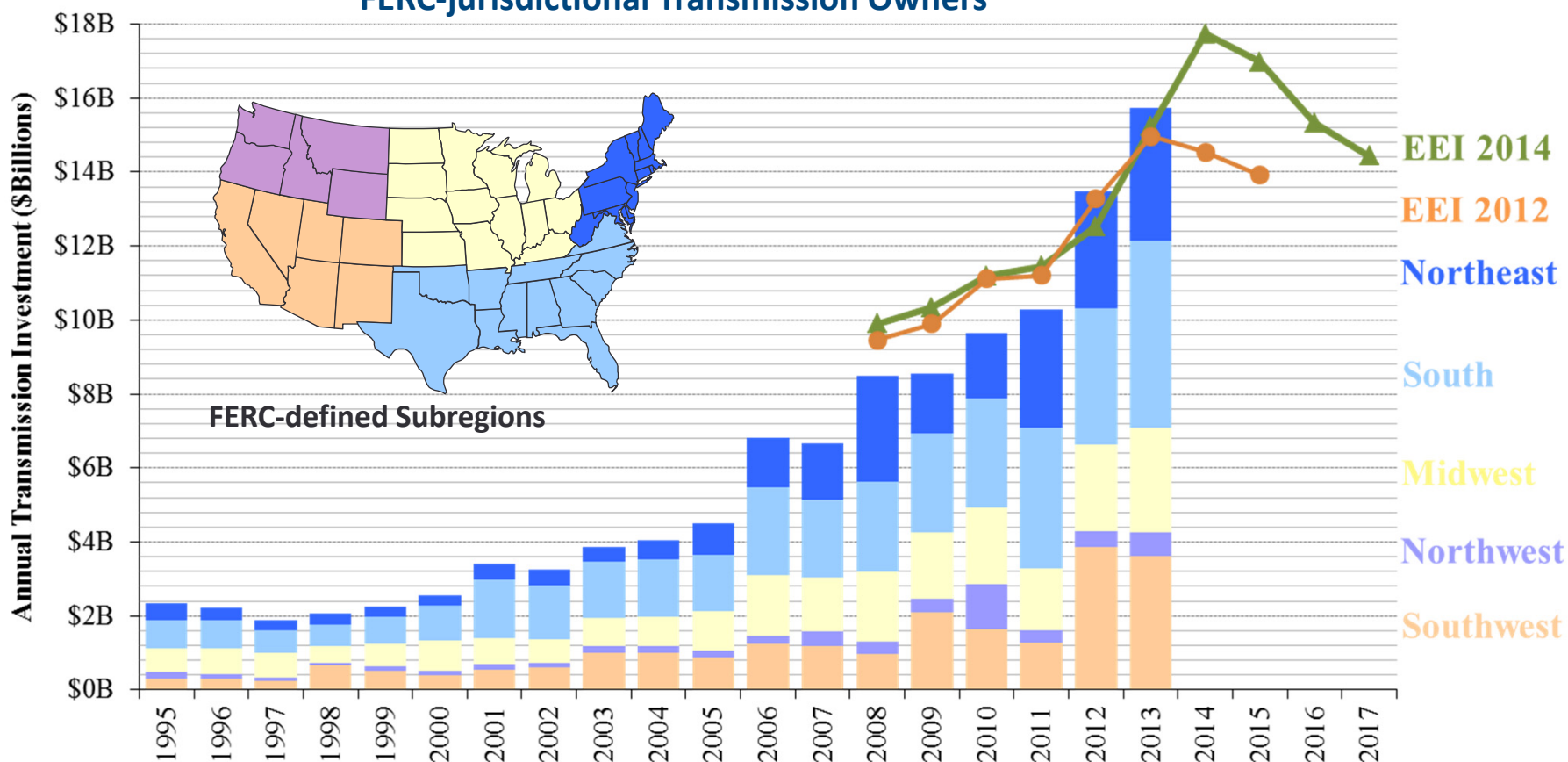
Our analysis of a wide range of sources and drivers* to document the dynamics of transmission needs and investment opportunities shows:

- \$120–160 billion of total projected U.S. transmission investment over next decade
- Significant regional differences in level, timing, and non-incumbent access of likely needs

* Sources include regional trend of historic transmission investments, industry projections of capex and circuit mile additions, announced major transmission projects (including merchant lines), EIPC study results, analyses of transmission investments specifically driven by coal plant retirements, renewable generation development, and aging infrastructure replacements

Transmission Investments Have Been Growing

1995–2017 Annual Transmission Investment by
FERC-jurisdictional Transmission Owners



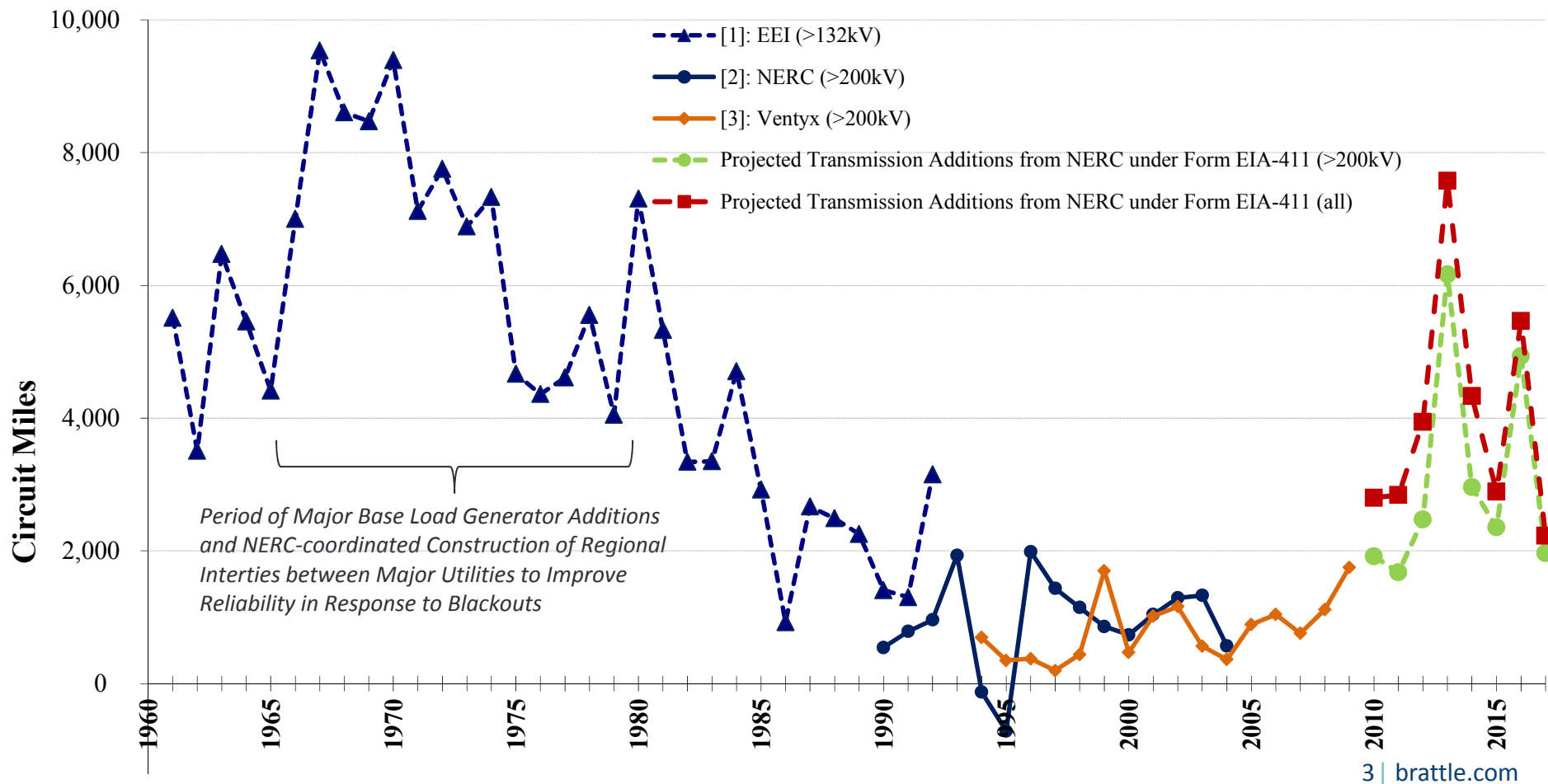
Sources and Notes: The Brattle Group's analysis of FERC Form 1 data compiled in Ventyx's Velocity Suite.

Based on EIA data available through 2003, FERC-jurisdictional transmission owners estimated to account for 80% of transmission assets in the Eastern Interconnection, and 60% in WECC and ERCOT. Facilities >300kV estimated to account for 60-80% of shown investments.

EEI annual transmission expenditures updated May 2014 shown (2008-2017) based on prior year's actual investment through 2012 and planned investment thereafter.

Historical Circuit-Mile Additions Document Aging Grid

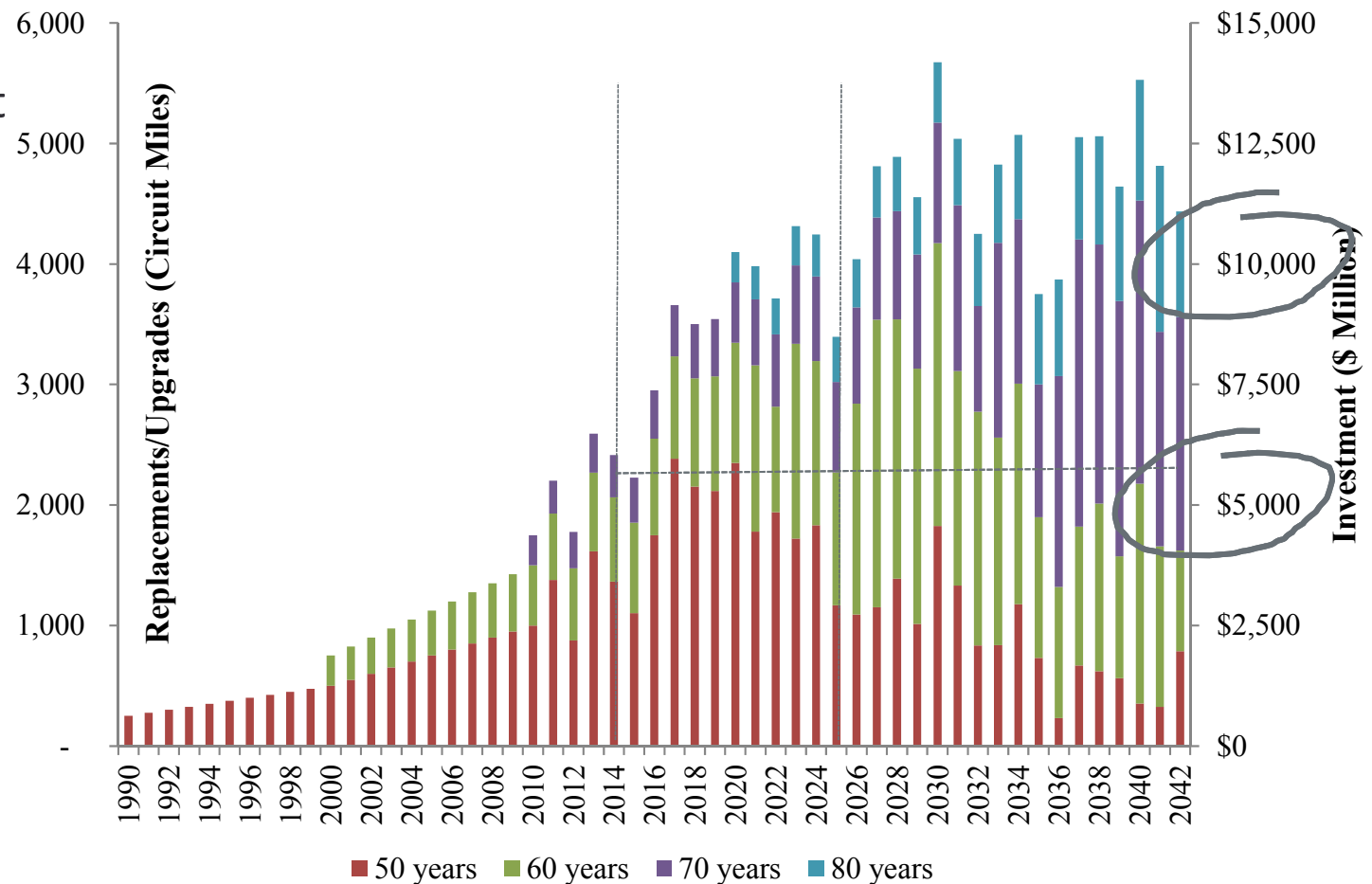
- Most of the existing grid was built 30-50+ years ago
- Even relatively high recent and projected circuit miles additions are below levels of additions in 1960s and 1970s



Replacing and Upgrading Aging Transmission Will Require Significant Investments

- If all facilities had to be replaced after 50 to 80 years, investment need could increase by \$5 billion/yr over next decade
- Some of these replacements may become large upgrades open to non-incumbents

Projected Circuit Miles Replaced/Upgraded and Total Projected Investment (\$m)



Assumes circuit mile costs equal to those of new lines

Renewables Additions to Meet RPS and the CPP will Drive Transmission Investment

- We estimate \$25-40 billion of transmission is still needed nationwide to accommodate ramp-up of existing state RPS requirements through 2025
- EPA estimates about 90 GW of new wind/renewables to meet Clean Power Plan, implying almost \$50 billion of likely additional transmission needs
- With alternative assumptions, 110 GW of new wind generation and \$60 billion of transmission could be needed to achieve the CPP's emission rate reductions

Estimated U.S. Transmission Investment Driven by Renewables through 2025

		Existing State RPS	EPA Estimate w/ CPP	Brattle Estimate w/ CPP
Estimated Wind Capacity	GW	50-70	90	110
Regional Transmission	\$billion	20-33	40	50
Interconnection related	\$billion	5-7	9	11
Total Transmission	\$billion	25-40	50	60

Sources and Notes:

Brattle Estimate with the CPP assumes 50% of required emission rate reduction achieved through added wind generation.

Transmission Investments Driven by Coal Retirements: Likely Relatively Modest

- Large-scale coal retirements projected even without EPA's CPP
 - EPA estimates 60 GW of coal retirements by 2025 in its Base Case (w/o CPP, driven by MATS, low gas prices, etc.)
- EPA estimates 50 GW of additional coal retirements due to CPP by 2025
- We estimated potential U.S. transmission needs driven by coal retirements based on PJM experience
 - \$10 billion without implementation of CPP
 - \$20 billion with CPP

Estimated Transmission Needs Driven by Coal Retirements through 2025

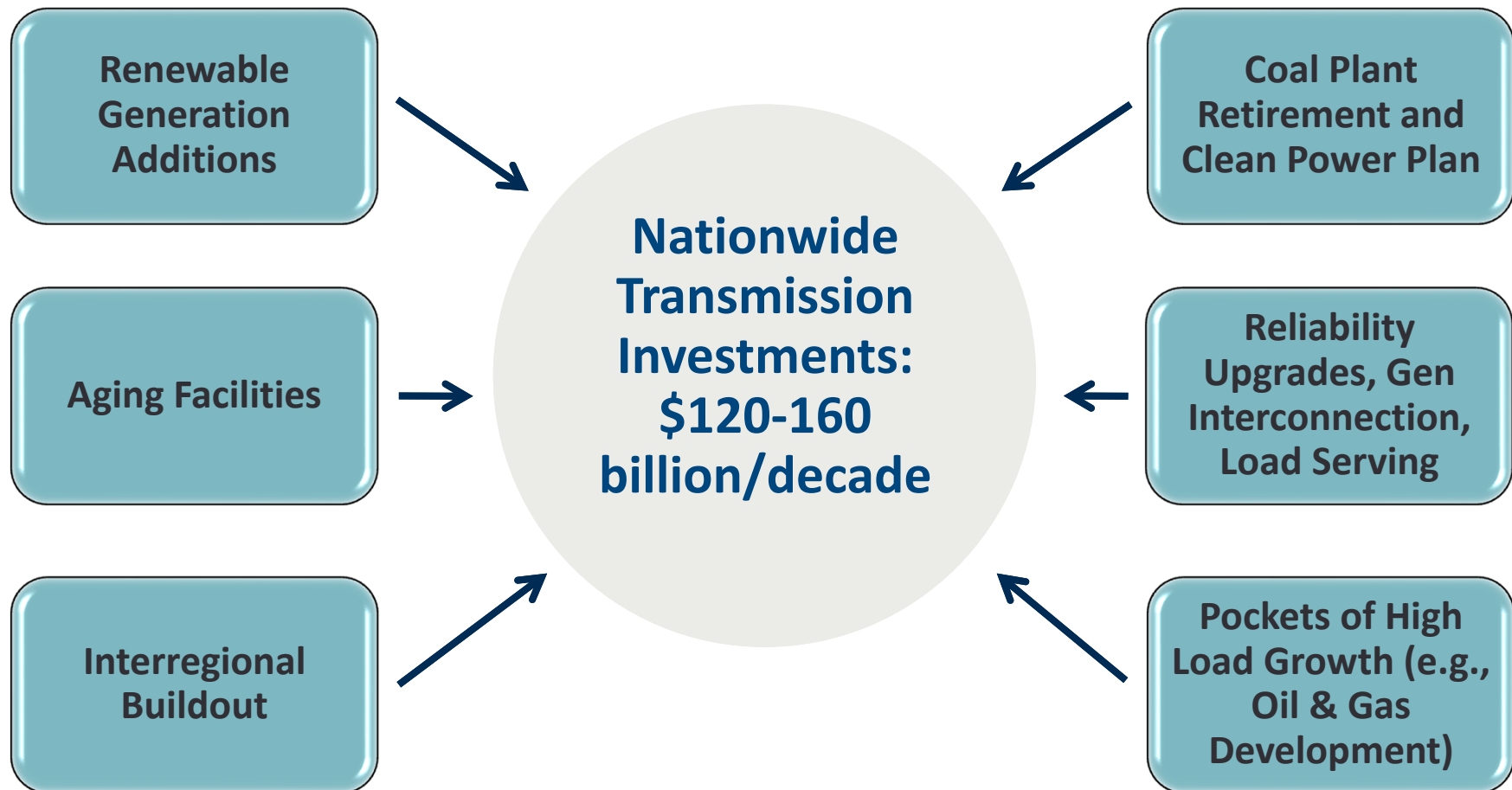
	EPA Projected Coal Retirements (GW)	Potential Transmission Investment (\$ billion)
Base Case (w/o CPP)	60	\$10
Under the CPP	110	\$20

Transmission Investment Driven by Coal Retirements: Key Uncertainties Remain

Key factors remain unclear about the relationship between coal retirements and transmission investment

- Uncertainty about final version of the Clean Power Plan
- Uncertainty about how states will choose to implement it
 - Regional cooperation will likely reduce the amount of retirements and transmission investment needed
- Uncertainty about coal-to-gas conversions
 - Regulated entities likely to face pressure to convert existing facilities
 - Conversions less likely in regions with deregulated retail markets because coal plant locations often not attractive for new merchant gas plants
- Older coal units most effected by regulation and declining economics
 - Likely connected to lower-voltage transmission lines
- Available low-cost transmission solution
- Expansion of EE and DR may manage peak loads and mitigate some need for transmission investment

Summary of Projected Transmission Investment Opportunities Nation-Wide

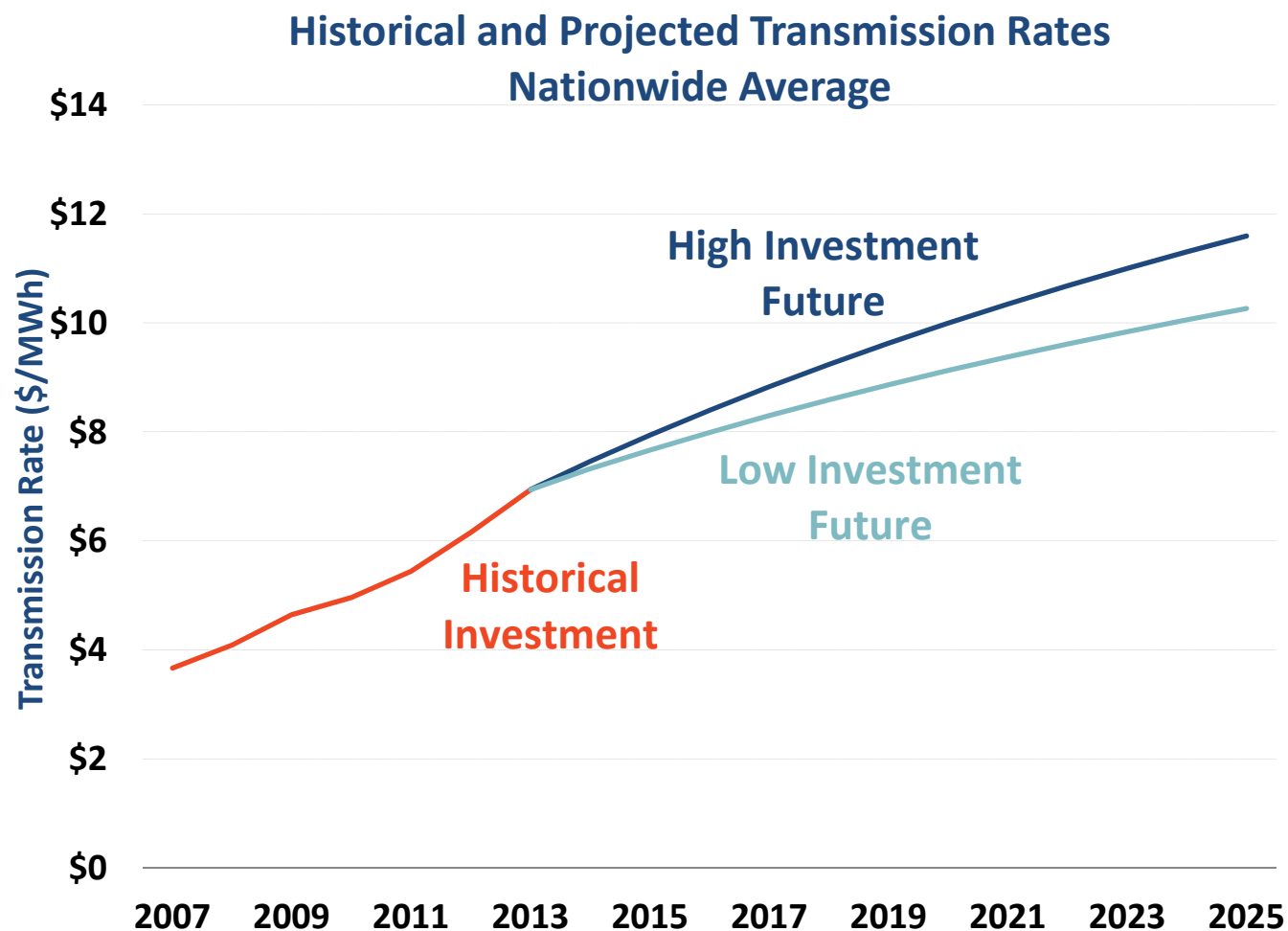


Sources and Notes:

The \$120-160 billion projection per decade was originally developed in conjunction with WIRES for “Employment and Economic Benefits of Transmission Investment in the US and Canada,” May 2011. This projection has since been refined and regionalized in several client-confidential analyses.

Rate Impact of Projected Transmission Investments

- Projected transmission investment needs have and will further increase transmission rates
- Increase starts at historically-low rates, that reflect two decades of little investment and need to upgrade aging infrastructure
- Increasing transmission rates will (at least partly) be offset by range of benefits, such as lower congestion-related costs and risk mitigation



Conclusions

Transmission investment will remain strong over the next decade

- Key Drivers: aging facilities, renewable additions, coal retirements replaced by new generation, pockets of strong load growth
- Significant opportunities for competitive transmission
- Timing, level, and non-incumbent access of investments will vary significantly across regions
- Unavoidable increases in transmission rates will require clear explanations of reasons and offsetting benefits

Uncertain impact of coal retirements on transmission needs

- Implementation details of EPA's Clean Power Plan still uncertain
- Coal retirements and shift in generation mix already occurring
- Transmission solutions may vary greatly in costs; targeted EE/DR can reduce transmission need
- Coal retirements will accelerate natural gas and renewable generation development opportunities with their own transmission needs

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Note:

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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.

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Ms. Judy Chang is an energy economist and policy expert with a background in electrical engineering and over 16 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 Master's in Public Policy from Harvard Kennedy School, is a member of the Board of Directors of the Massachusetts Clean Energy Center, and the founding Executive Director of New England Women in Energy and the Environment.

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