Cost Savings Offered by Competition in Electric Transmission

Experience to Date and Potential Value for Electricity Consumers

PRESENTED TO

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PRESENTED BY
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THE Brattle GROUP

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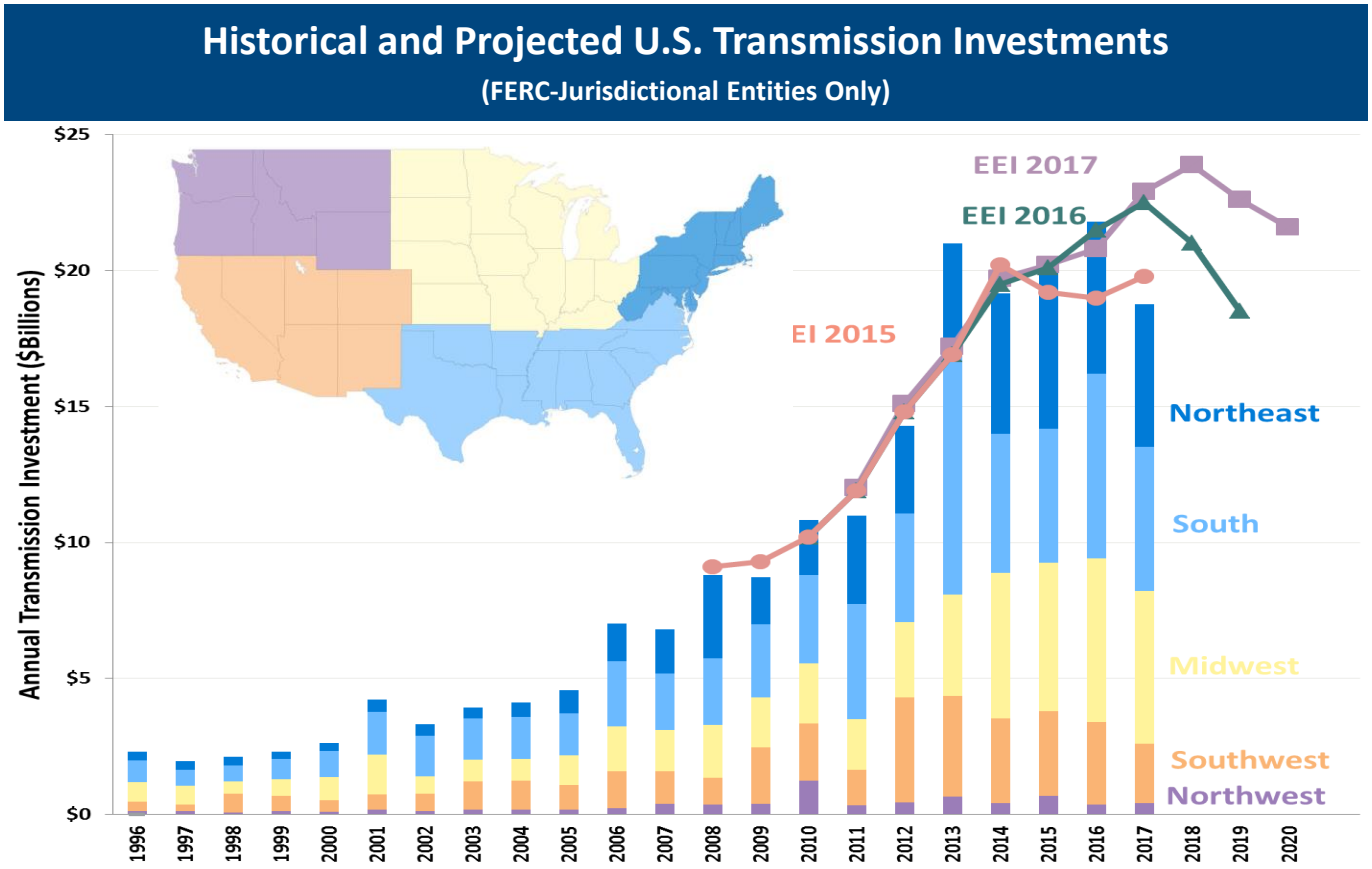
This presentation is based on the authors' analyses of publicly-available transmission data reported to FERC and ISO/RTO transmission project tracking reports, as assembled for prior client engagements and conference presentations. The analyses around competitive transmission process was commissioned by LS Power.

Historical and Projected U.S. Transmission Investment by FERC-Jurisdictional Entities

Annual U.S. transmission investments are approximately **$20 billion/year** in the last five years (compared to ~$2 billion/year in late 1990s



Sources and Notes:

The Brattle Group © 2018. Regional Investment based on FERC Form 1 investment compiled in Ventyx's Velocity Suite, except for ERCOT for years 2010 - 2017, which are based on ERCOT TPIT reports. 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. Facilities >300kV estimated to account for 60-80% of shown investments. EEI annual transmission expenditures updated December 2017 shown (2011 -2020) based on prior year's actual investment through 2016 and planned investments thereafter.

Majority of U.S. Transmission Investments in ISO/RTO Regions

Transmission investments in markets operated by FERC-jurisdictional **ISO/RTOs and ERCOT account for 85%** of current transmission investments

Transmission investments in ISO/RTO regions have grown by 10-16% annually, and 6-10% annually in non-ISO/RTO regions.

U.S. Annual Transmission Investments (2010–2017) and Growth Since 1999

	1999	2010	2011	2012	2013	2014	2015	2016	2017	2013-2017 Total	1999-2017 CAGR
CAISO	$0.33	$1.7	$0.9	$3.5	$3.2	$2.6	$2.5	$2.4	$1.8	**$12.6**	**10%**
ISO-NE	$0.09	$0.7	$0.6	$1.4	$1.8	$1.4	$1.7	$1.4	$1.2	**$7.5**	**15%**
MISO	$0.34	$1.4	$1.0	$1.3	$2.5	$2.7	$3.0	$4.0	$3.3	**$15.5**	**14%**
NYISO	$0.08	$0.5	$0.7	$0.3	$0.4	$0.5	$0.5	$0.5	$0.6	**$2.6**	**12%**
PJM	$0.46	$1.9	$3.4	$2.9	$4.1	$6.6	$7.3	$7.1	$6.4	**$31.5**	**16%**
SPP	$0.11	$0.8	$0.6	$1.2	$1.0	$2.1	$0.9	$1.4	$0.9	**$6.2**	**12%**
Subtotal FERC-jurisdictional ISO/RTOs	**$1.43**	**$7.0**	**$7.3**	**$10.6**	**$12.9**	**$15.9**	**$15.8**	**$16.9**	**$14.4**	$75.9	**14%**
ERCOT	$0.14	$0.8	$1.2	$1.0	$5.3	$0.9	$0.9	$2.0	$1.1	**$10.2**	**12%**
Subtotal U.S. ISO/RTOs	**$1.56**	**$7.8**	**$8.4**	**$11.7**	**$18.2**	**$16.8**	**$16.8**	**$18.9**	**$15.5**	**$86.1**	**14%**
Other WECC	$0.32	$1.7	$0.7	$0.8	$1.2	$0.8	$1.3	$1.0	$0.9	**$5.2**	**6%**
Southeast & Other	$0.43	$1.3	$1.8	$1.8	$1.6	$1.6	$1.9	$1.9	$2.3	**$9.4**	**10%**
Total US Reported to FERC and in ERCOT	**$2.31**	**$10.8**	**$11.0**	**$14.3**	**$21.0**	**$19.1**	**$19.9**	**$21.8**	**$18.8**	$100.7	**12%**

Main Drivers of Transmission Needs

- Serve growing load
- Generation interconnections
- Local and regional reliability
- Congestion relief

Traditional Drivers

- Access to low-cost renewable and clean energy
- Capture renewable energy and fuel diversity
- Help meet regional economic and public policy needs
- Cost reductions offered by better interregional coordination
- Mitigate risks and create valuable options to address uncertainties proactively

New Drivers

Well-Planned Transmission Reduces 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 clean energy 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.

Key Shortfalls in Traditional Transmission Planning

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

1. Approximately half of the transmission investments made in ISO/RTO regions **do not go through comprehensive ISO/RTO planning process**
2. 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
3. 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
4. **Interregional planning processes are ineffective** and are generally unable to identify valuable transmission investments that would benefit two or more regions
5. **Very limited competitive forces** in transmission planning and development

Additional challenges exist related to regional cost recovery and state-by-state permitting processes

Scope of ISO/RTO Oversight in U.S. Transmission Investments

Of $75 billion in transmission investments by FERC-jurisdictional TOs in ISO/RTO regions between 2013 to 2017, **~47% was made without comprehensive ISO/RTO and stakeholder engagement** through the regional planning process

- Currently, transmission investments based on local planning by incumbent TOs are not subject to full ISO/RTO review
- FERC's September 19, 2019 Order denied rehearing and ruled that only transmission that yield "expansion" are subject to full regional planning requirements

Transmission Investments Subject to Full or Limited Review in ISO/RTO Regional Planning Processes

	Years Reviewed	FERC Jurisdictional Additions by Transmission Owners (nominal $million, *based on FERC Form 1 Filings*)	Investments Approved Through Full ISO/RTO Planning Process (nominal $million)	% of Total FERC Jurisdictional Investments Approved Through *Full* ISO/RTO Planning Process	% of Total FERC Jurisdictional Investments with *Limited* ISO/RTO Review
CAISO	2014 - 2016	$7,528	$4,043	54%	46%
ISO-NE	2013 - 2017	$7,488	$5,300	71%	29%
MISO	2013 - 2017	$15,530	$8,068	52%	48%
NYISO	2013 - 2017	$2,592	**n/a**	**n/a**	**n/a**
PJM	2013 - 2017	$31,469	$14,458	46%	54%
SPP	2013 - 2017	$6,202	$4,226	68%	32%
Total	-	**$70,810**	**$36,095**	**53%**	**47%**

Sources & Notes: *Data based on FERC Form 1 and ISO/RTO Tracking Reports. CAISO data reflects only select transmission additions/approved investments of PG&E, SCE, and SDG&E for 2014 -2016, based on available data. Aggregate Investment for each ISO/RTO reflects total FERC Form 1 transmission additions over indicated time periods. Investments approved by ISO/RTO reflects total value of transmission additions placed in-service over indicated time periods, approved through ISO/RTO processes.*

Competition in Transmission Development

FERC's Order No. 1000 was intended to promote "more efficient or cost-effective transmission development" by increasing competition.

Developers compete to provide and build innovative solutions to meet needs

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

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

- Planning entities identify need and specify solutions and projects
- Planning entities select developer to finance, construct, and own project based on factors including bid prices
- **Examples: CAISO, MISO, SPP, ERCOT, Brazil, Alberta, Ontario,**

Experience with Competitive Solicitations for Transmission in U.S.

Across the U.S., **only 3% of FERC-jurisdictional transmission investments has been subject to full competitive processes** between 2013 through 2017.

On average, ~$540 million/year out of ~$20 billion/year of transmission investment has been subject to full competitive process in the U.S.

Competitively-Developed Projects in FERC-Jurisdictional Regions In 2013-2017 (Project costs in nominal $million)								
	CAISO	ISO-NE	MISO	NYISO	PJM*	SPP	Non-RTO	Total
2013	$144	$0	$0	$0	$0	$0	$0	$144
2014	$148	$0	$0	$0	$90	$0	$0	$238
2015	$425	$0	$0	$0	$912	$0	$0	$1,337
2016	$133	$0	$50	$0	$471	$8	$0	$662
2017	$0	$0	$0	$181	$142	$0	$0	$323
Total Estimated Competitive Project Costs Selected in 2013-2017	**$851**	**$0**	**$50**	**$181**	**$1,615***	**$8**	**$0**	**$2,705**
Total Reported FERC Form 1 Transmission Investment in 2013-2017	$12,600	$7,500	$15,500	$2,600	$31,500	$6,200	$14,600	$90,500
Total Estimated Competitive Project Costs Selected in 2013-2017 (% of 2013-2017 Total Investment)	**6.8%**	**0.0%**	**0.3%**	**7.0%**	**5.1%***	**0.1%**	**0.0%**	**3.0%**

* In estimating the total costs of competitive projects approved in PJM, we include 136 projects awarded under competitive windows to incumbent transmission owner with total costs of $952 million, of which 132 projects are upgrades to existing facilities that were not open to competitors.

Projects Selected Through Competitive Process by ISO/RTOs (as of March 2019)

Experience to date shows strong competition across many companies

- 20 projects in the U.S. and 3 in Canada
- From 2013-17, PJM received 794 proposals competing to meet needs
- PJM approved 139 projects of which 132 were upgrades; 3 awarded to non-incumbents

* While Imperial Irrigation District (the selected developer of the Imperial Valley project) is the incumbent in the
Imperial Valley Region, it is not a CAISO PTO and thus not an incumbent within the CAISO footprint.
** Transource is a joint venture between AEP and Great Plains Energy.

Processes Completed

ISO/RTO	Processes Completed	Process Type	Awards
CAISO	10	Projects	10
MISO	2	Projects	2
SPP	1	Projects	1
PJM	16	Solutions	139
NYISO	2	Solutions	3
ISO-NE	0	Solutions	0
All Regions	**31**		**155**

Competitive Transmission Project Summary

ISO/RTO	Project	Year of Decision	Selected Developer	Award to Incumbent?
CAISO	Gates-Gregg project (subsequently cancelled)	2013	PG&E/MidAmerican w/ Citizen Energy	Yes
CAISO	Imperial Valley Project	2013	Imperial Irrigation District	No*
CAISO	Sycamore-Peñasquitos 230 kV	2014	SDG&E w/ Citizen Energy	Yes
CAISO	Delaney-Colorado River Project	2015	DCR Transmission	No
CAISO	Estrella Substation Project	2015	NextEra	No
CAISO	Wheeler Ridge Junction Project	2015	PG&E	Yes
CAISO	Suncrest Project	2015	NextEra	No
CAISO	Spring Substation	2015	PG&E	Yes
CAISO	Harry Allen-Eldorado Project	2016	Desert Link	No
CAISO	Miguel Substation	2014	SDG&E	Yes
MISO	Duff-Coleman 345 kV	2016	LS Power w/ Big Rivers	No
MISO	Hartburg-Sabine Junction 500 kV	2018	NextEra	No
NYISO	Western NY Public Policy Transmission	2017	NextEra	No
NYISO	AC Transmission Public Policy Segment A	2019	North America Transmission and NYPA	No
NYISO	AC Transmission Public Policy Segment B	2019	Niagara Mohawk and New York Transco	Yes
PJM	Artificial Island Project	2015	LS Power	No
PJM	Thorofare Project	2015	Transource	No**
PJM	AP South Market Efficiency Project	2016	Transource w/ BGE and Allegheny Power	No**
PJM	136 Projects Awarded to Incumbents (132 Upgrades)	2014-2017	Various	Yes
SPP	North Liberal – Walkemeyer 115 kV (subsequently cancelled)	2016	Mid Kansas Electric	Yes
AESO	Fort McMurray West 500 kV	2014	Alberta PowerLine Limited Partnership	Yes
IESO	East West Tie Line	2013	NextBridge Infrastructure	No
IESO	Wataynikaneyap Power Project	2015	Fortis Inc.	No

Criteria for Entering Competitive Processes in ISOs/RTOs

ISO/RTO qualifications and exclusion criteria greatly reduce the scope of projects eligible for competitive processes. Experience shows scope can be expanded.

	CAISO	ISO-NE	MISO	NYISO	PJM	SPP
Types of Projects Eligible for Competition	Reliability, Economic, Public Policy	Reliability, Economic, Public Policy	Market Efficiency, Multi-Value (MVP)	Reliability, Economic, Public Policy	Reliability, Economic, Public Policy	ITP, High Priority, Interregional
Exclusions						
Exclusions for Reliability Projects		✓ (Based on Need Date)	✓*		✓ (Based on Need Date)	✓ (Based on Need Date)
Exclusions for Local Cost Allocated Projects (per Order 1000)	✓	✓	✓	✓	✓	✓
Exclusion of Upgrades (per Order 1000)	✓	✓	✓	✓	✓	✓
Exclusions Based on Voltage						
Voltage > 300 kV						
Voltage 200-300 kV			✓** (For MEP)			
Voltage 100-200 kV	✓		✓** (For MEP)		✓***	
Voltage < 100 kV	✓	✓	✓**		✓***	✓

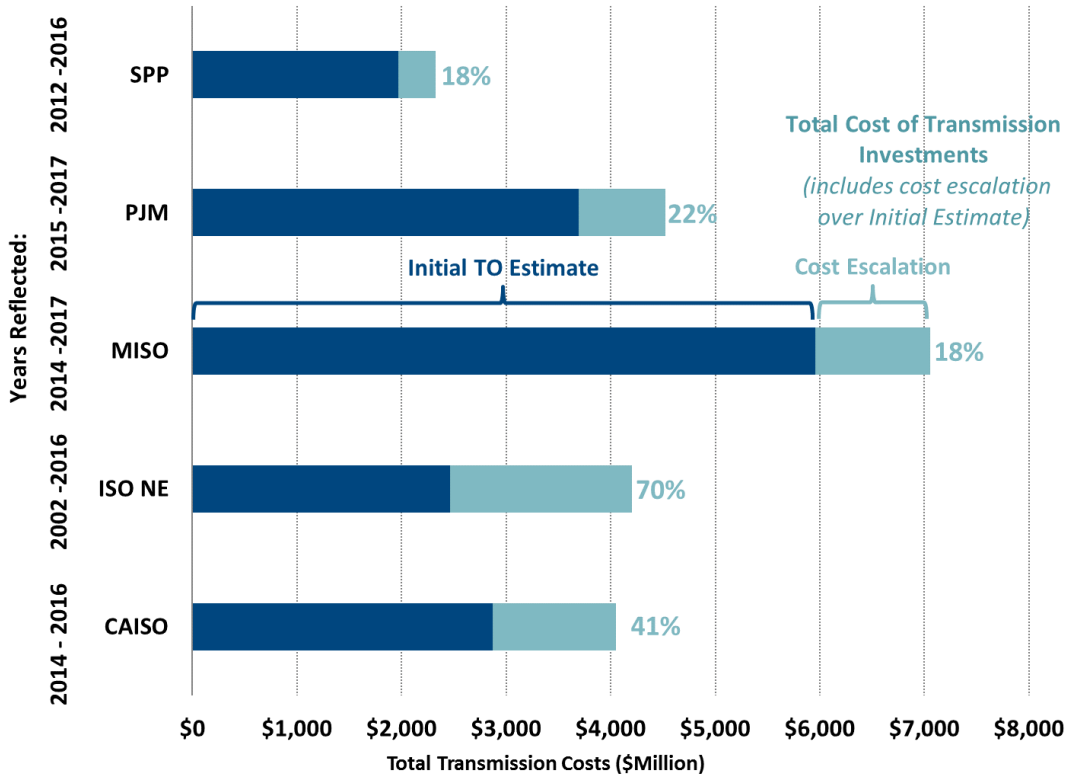
Notes: Additionally, competitive transmission may be precluded in certain states, due to state Right of First Refusal (ROFR) provisions. *In MISO, projects that are only classified as Baseline Reliability Projects are locally allocated (regardless of voltage), making them ineligible for competitive processes. Projects designated as Baseline Reliability Projects and MEPs/MVPs are cost-allocated as though they are MEPs/MVPs. **MISO limits competition to MEPs and MVPs; MEPs must have a total cost of at least $5 million and a minimum voltage of 230 kV; MVPs must have a total cost of at least $20 million and a minimum voltage of 100 kV; see MISO Tariff Attachment FF, Sections II.B, and II.C. ***PJM has exceptions to these exclusions on lower voltage facilities for specific types of reliability violations. These exceptions are detailed in PJM Manual 14F Section 5.3.4.

Cost Escalations of Traditionally-Developed ISO/RTO Transmission Projects

Many transmission projects experience cost escalations:

- Data for initial project cost estimates and final project costs of transmission projects show **average cost escalations 34%**
- These escalations reflect inflation, routing or project changes, and siting complications
- The absence of cost-tracking mechanisms in some ISO/RTOs (CAISO and NYISO) makes it difficult to analyze project cost increases
  (CAISO data from FERC Complaint, EL17-45)
- Having consistent and transparent project cost tracking and reporting would be important

Historical Cost Escalations of Traditionally-Developed Projects in FERC-Jurisdictional ISO/RTOs



* Weighted average based on *competitively selected transmission investments* in each ISO/RTO. ISO-NE has yet to select any transmission project through its competitive planning processes. Therefore, the weighted average of historical cost escalation of traditionally-developed *projects* shown above excludes ISO-NE projects' observed historical cost-escalation.

Potential Cost Savings from Competitive Transmission Processes

Experience with 16 projects selected through the ISO/RTO competitive planning processes show potentially large cost advantages of competition

- On average, the winning bids of these 15 competitive transmission projects have been priced **40% below** the ISO/RTOs' or incumbent TO's initial project cost estimates
- Similar bid cost advantages observed in Alberta
- All 16 projects are still under development (in-service dates post-2019), so final costs are not yet known
- Selected developer offer **cost caps or cost-containment** measures, reducing the risk of significant cost increases

Differences in Competitive Bids and Initial Cost Estimates
for Competitive Processes of FERC-Jurisdictional ISO/RTOs

RTO	Number of Competitive Projects	ISO/RTO or Incumbent Estimate of Project Cost ($million)	Winning Bid of Competitive Projects ($million)	Average Cost Advantage of Competitive Bids
CAISO*	10	$1,180	$833	29%
ISO-NE	0	n/a	n/a	n/a
MISO	2	$181	$154	15%
NYISO	1	$232	$181	22%
PJM*	2	$692	$280	60%
SPP	1	$17	$8	50%
Total	**15**	**$1,948**	**$1,171**	**40%**

* Note: The only competitively selected project in NYISO project is not reflected in the average cost advantage. Additionally, just 1 of 2 competitively selected projects in PJM projects are reflected in the average cost advantage.

Cost advantage calculated as:

- Bid-based processes (MISO, SPP, CAISO): cost difference = between costs of winning bids and ISO/RTO's or TO's initial reference cost estimate for the project
- Sponsorship-based processes (PJM and NYISO): cost difference = between winning bid and lowest-bid of incumbent TOs

Experience with Completed Competitive Transmission Projects

While the transmission projects competitively developed under Order 1000 have not yet been completed, there is significant experience with competitively bid projects that have been completed:

- **Path 15, California**: 84 mile, 500 kV project in CAISO completed in 2004 on time and under budget at a cost of approx. $250 million, 18% below the incumbent's $306 million initial cost estimate
- **Fort McMurray, Alberta**: 508 km, 500 kV project in Alberta was completed in March 2019 on budget ($1.6 billion) and three months ahead of schedule, providing Alberta ratepayers over $400 million in savings (per AESO estimate)
- **U.K. Offshore Transmission**: the U.K. regulator estimated that since 2009 three rounds of competitive solicitations resulted in savings ranging from £683 million to £1,092 million (averaging 23%–34%, net of the cost of conducting the process)
- **Brazil**: since 1999, auctions for 87 transmission projects (receiving 399 bids by 112 companies and consortiums) on average yielded estimated cost savings of 25% (per study prepared by Imperial College and University of Cambridge for U.K. regulator)

Sources: see Brattle competitive transmission report, pages 44 and 49-51.

Customer Savings from U.S. and International Experience with Competitive Processes

The potential cost savings from expanding competitive processes in the U.S. could range from approximately 20% to 30%, consistent with savings achieved with similar competitive transmission processes in Canada, the U.K., and Brazil.

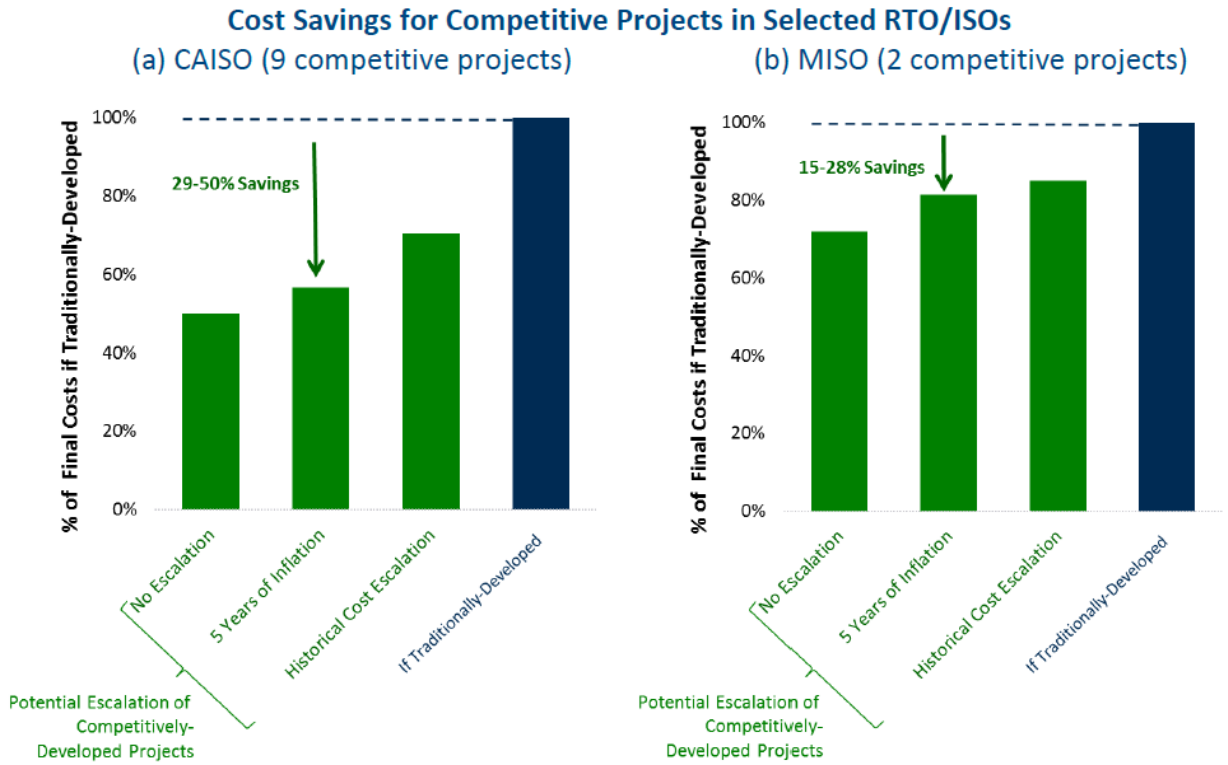
Region	Estimated Cost Savings	No. of Projects	Estimated Cost of Winning Proposal	Notes
CAISO	29–50%	9	$833 million	Winning proposal costs compared to CAISO initial cost estimate; assumed range of cost escalation of winning bid from no escalation to escalation of traditionally-developed projects in CAISO (+41%)
MISO	15–28%	2	$154 million	Winning proposal costs compared to MISO initial cost estimate; assumed range of cost escalation of winning bid from no escalation to escalation of traditionally-developed projects in MISO (+18%)
PJM	60–67%	1	$280 million	Winning proposal cost (including necessary incumbent upgrades) compared to lowest-cost solution offered by incumbent in the initial proposal window; assumed range of cost escalation of winning bid from no escalation to escalation of traditionally-developed projects in PJM (+22%)
SPP	50–58%	1	$8 million	Winning proposal cost compared to SPP initial cost estimate; assumed range of cost escalation of winning bid from no escalation to escalation of traditionally-planned projects in SPP (+18%); project cancelled following selection
NYISO	22%	1	$181 million	Winning proposal cost compared to lowest-cost bid from incumbent
IESO	16%	1	CAD$777 million	Winning proposal cost compared to bid from incumbent
AESO	21%	1	CAD$1,614 million	Winning proposal cost compared to AESO initial cost estimate; costs of the winning bid later increased due to changes in route
U.K.	23–34%	15	~£3,000 million	Winning bid cost estimate compared to merchant and regulated counterfactuals estimated by Ofgem
Brazil	~25% (20–40%)	Many	$28 billion	Based on Brazil's experience since 1999 holding auctions for all projects over 230 kV; over 50,000 km of lines built through this process

Potential Customer Savings from Competitive Transmission Planning Processes

The experience in U.S. indicates a significant potential for customer savings

- If competitive projects can be developed as bid (without further cost escalations), savings would be 28%-50% relative to the costs had this projects been traditionally-developed
- If costs of competitive projects escalate like traditionally-developed projects, the savings would still be between 15%-30%

Potential Cost Savings from Competition



Prof. Paul L. Joskow's Take on Competitive Transmission Since Order 1000

Prof. Joskow's (M.I.T) recent paper on competitive transmission comes to very similar conclusions:

- "there is quite a bit to learn from the 16 projects selected through an organized competitive procurement process by ISOs since Order 1000 went into effect"
- Non-incumbents' "projects often have significantly lower cost estimates than the incumbent's, often combined with cost containment commitments"
- "The competitive procurements demonstrate that competing transmission developers can reduce expected costs by coming up with innovative designs to resolve transmission needs identified through the ISO regional planning process, taking on more performance risk… etc"
- "Competitive procurement may also induce incumbents and non-incumbents to sharpen their pencils"
- "While the jury is necessarily still out on whether competitive procurement leads to lower costs to meet specific transmission needs, I think that there are good reasons to believe that it likely does. The evidence from other countries … is consistent with this view."

Source: "Competition for Electric Transmission Projects in the U.S.: FERC Order 1000," March 16, 2019. Available at: https://economics.mit.edu/files/16832

Costs of Competitive Transmission Planning Processes

Costs for implementing and administering competitive processes for the ISOs/RTOs

- SPP reports internal costs of the competitive process for the North Liberal–Walkemeyer 115 kV project ~$500,000, ~3% of the relatively small project's $17 million cost estimate
- As of December 2017, PJM covered 97% of its $1.7 million of total 2016–2017 evaluation costs
- PJM approved 39 projects from these proposal windows, which amounts to ~$44,000 of evaluation costs per approved project

PJM Submission Fees to Cover Implementation and Administrative Costs

Project Size	Submission Fee
<$20 million	$0
$20 – $100 million	$5,000
>$100 million	$30,000

- Project developers incur additional costs when developing proposals
  - Both ISO administrative costs and developer costs are absorbed by developers (and will ultimately be reflected in bids)

SPP estimated that developers spent $300,000 to $400,000 for each of the 11 proposals submitted to its solicitation for North Liberal – Walkemeyer 115 kV, for a total of $3.3 million to $4.4 million of developer costs. Similar to SPP's costs of administering the competitive solicitation process, these costs are not directly passed through to customers. Prepared Statement of Paul Suskie, Executive Vice President and General Counsel, Southwest Power Pool, Inc., Before the Federal Energy Regulatory Commission, Docket No. AD16-18-000.

Implications for Customers and Electric Industry

As documented in many other studies, making valuable transmission investments provide significant overall cost savings through a wide range of benefits.

Increasing the scope of competition would provide additional benefits:

- **Customer Benefits**: With average savings of 25%-30%, expanding the scope of competition from 3% to 33% of total transmission investments would yield **customer benefits of $6-$9 billion over five years**
- **Innovation brings long-term advances** to the electric industry, which will further benefit customers and transmission providers

Estimated Savings from Competitive Processes (% of Transmission Costs)	**20%**	**30%**
Estimated 5-year US-wide Transmission Investment	$100 billion	$100 billion
Current Share of Competitive Projects (% of Total Investment)	3%	3%
Estimated Cost Savings over 5 years		
25% of Transmission Investment Subject to Competition	$4.4 billion	$6.6 billion
33% of Transmission Investment Subject to Competition	$6.0 billion	$9.0 billion

Bio and Contact Information

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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 power market designs, contract issues, and transmission rate design. She has authored numerous reports detailing the economic issues associated with system planning, including comparing the costs and benefits of transmission; renewable integration; and value of electricity storage. In addition, she assists clients in comprehensive organizational strategic planning, asset valuation, finance, and regulatory policies.

She holds a BSc. In Electrical Engineering from University of California, Davis, and Masters in Public Policy from Harvard Kennedy School. She is co-leading Brattle's energy practice and is the founding Director of New England Women in Energy and the Environment.

Appendix

Estimates Used to Calculate Cost Escalations

Our analysis of potential savings from competitive transmission development processes uses initial planning estimates as a common reference point:

1. Initial planning cost estimates for competitive projects are *compared with* the price of winning bids (plus a range of plausible cost escalations)
2. Initial planning cost estimates for traditional projects are *compared with* the cost of completed projects (to determine typical cost escalations)

In contrast, Concentric relies on updated cost estimates, yielding unreasonable results without providing a common reference point.

Example: Replication of Concentric's approach for a certain MISO Project

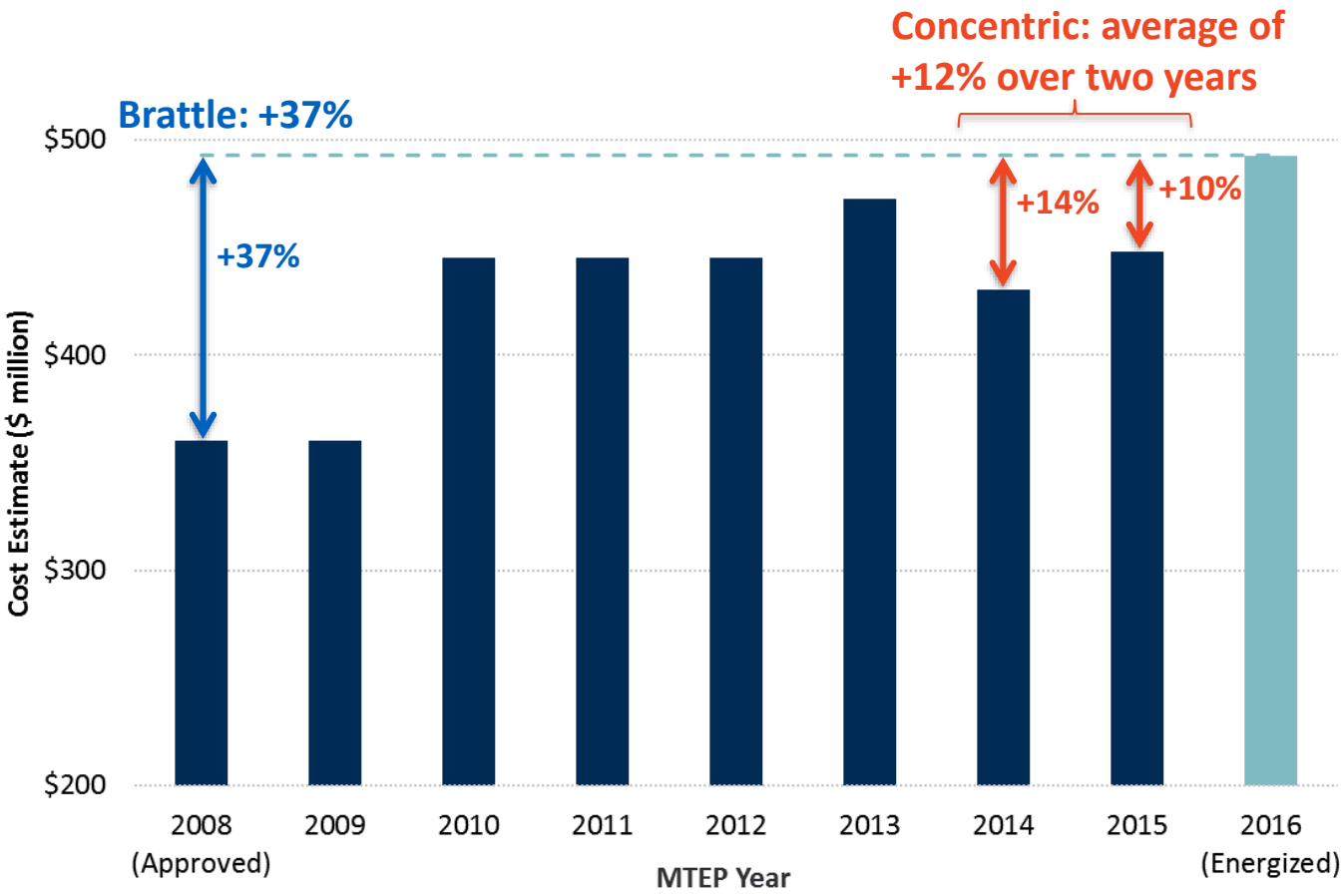
- Brattle approach: MISO project was approved in 2008 at an initial cost estimate of $360 million and placed into service in 2016 for $493 million (a 37% escalation)
- Concentric approach: compares MISO's updated 2014 and 2015 cost estimates of $430 and $448 million to final 2016 project cost of $493 million (12% escalation)

MISO has recognized cost escalations similar to our 18% overall estimate:

- 2017 MVP Update (p.5): "Total portfolio costs have increased from $5.56 billion in MTEP11 to $6.65 billion in MTEP17." That is a 19.6% cost increase.

An Example for Comparison

- Concentric's approach of counting the same project multiple times, year after year, distorts the calculations for each project
- Using later and updated cost estimates guarantees a lower cost escalation



Examples of "Cost Caps" offered in Competitive Transmission Solicitations

Cost caps offered by LS Power in its successful bids illustrate the nature of bid-based cost control mechanisms:

- **Artificial Island Project (PJM)**: $146 million cost cap escalated with inflation until construction start. Covers all LS-Power-related construction costs, including those associated with obtaining permits, acquiring land, and environmental assessments and mitigations. Exclusions force majeure-type events, taxes, financing, and any incremental costs to the project caused by PJM-directed changes.
- **Harry Allen–Eldorado 500 kV (CAISO)**: Project cost is capped at $147 million in 2020 dollars. Exclusions for force majeure events, financing costs, and cost increases caused by changes mandated by the ISO or from incumbent transmission owners at their substations.
- **Duff-Coleman 345 kV (MISO)**: Total rate base capped at $58.1 million, with exclusions for force majeure events, on-going O&M costs, and material changes to the scope of work.

Exclusions to cost caps allow for some cost escalations, but we anticipate these escalations to be more limited than for traditionally-developed projects without such cost caps (and a much wider set exclusions)

- The 20-30% range of our estimated cost savings is based on three possibilities of cost escalations: (1) no escalation beyond offer price; (2) inflation-based escalation; and (3) same escalation as those experienced by traditionally-developed projects in the region.

Risk Sharing for Competitive Projects as Proposed by NY PSC

The competitive bidding process for public policy transmission in New York includes a PSC-mandate that in addition to bids based on traditional full cost recovery, bids also need to be prepared consistent with the NYPSC's "cost-overrun-sharing incentive regime":

- If actual costs are above the bid, developers bear 20% of the actual cost over-runs, ratepayers bear 80%
- If actual costs are below the bid, developers retain 20% of the savings
- The bid price caps FERC incentives: if the developer seeks incentives from FERC above the base ROE otherwise approved by FERC, the developer will not receive any incentives above the base ROE on cost overruns over the bid price

Source: NYPSC, CASE 12-T-0502, et al., Dec 17, 2015.

Additional Reading

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

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

Chang, Pfeifenberger, and Hagerty, "The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments," WIRES and The Brattle Group, July 2013, online at: http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Rpt%20Benefits%20Transmission%20July%202013.pdf

Pfeifenberger, Chang, and Tsoukalis, "Dynamics and Opportunities in Transmission Development, presented at TransForum East, December 2, 2014, at http://www.brattle.com/system/publications/pdfs/000/005/089/original/Dynamics_and_Opportunities_in_Transmission_Development.pdf?1417535596

Chang, Pfeifenberger, Newell, Tsuchida, Hagerty, "Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process," October 2013, at http://www.brattle.com/news-and-knowledge/news/brattle-consultants-assist-ercot-in-scenario-planning-and-improving-its-long-term-transmission-planning-process

Chang, "Implications of the Increase in Wind Generation for Alberta's Market: Challenges of Renewable Integration," presented at 13th Annual Alberta Power Summit, Calgary, Alberta, November 28, 2012.

Chang, "Challenges of Renewable Integration: Comparison of Experiences," presented at Transmission Executive Forum West 2012, Meeting Public Policy Objectives through Transmission Investment, October 22, 2012.

Pfeifenberger and Hou, "Seams Cost Allocation: A Flexible Framework to Support Interregional Transmission Planning," April 2012, online at: http://www.brattle.com/system/publications/pdfs/000/004/814/original/Seams_Cost_Allocation_Report_Pfeifenberger_Hou_Apr_2012.pdf?1378772132

Pfeifenberger, Johannes, "Transmission Investment Trends and Planning Challenges," presented at the EEI Transmission and Wholesale Markets School, Madison, WI, August 8, 2012, online at: http://www.brattle.com/system/publications/pdfs/000/004/432/original/Transmission_Investment_Trends_and_Planning_Challenges_Pfeifenberger_Aug_8_2012_EEI.pdf?1378772105

Pfeifenberger, Hou, Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada, on behalf of WIRES, May 2011, online at: http://www.brattle.com/system/publications/pdfs/000/004/501/original/Employment_and_Economic_Benefits_of_Transmission_Infrastructure_Investmt_Pfeifenberger_Hou_May_2011_WIRES.pdf?1378772110

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Our services to the electric power industry include:

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