Generation Interconnection and ELCC Values for Variable Resources

PRESENTED BY

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PREPARED FOR

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Brattle

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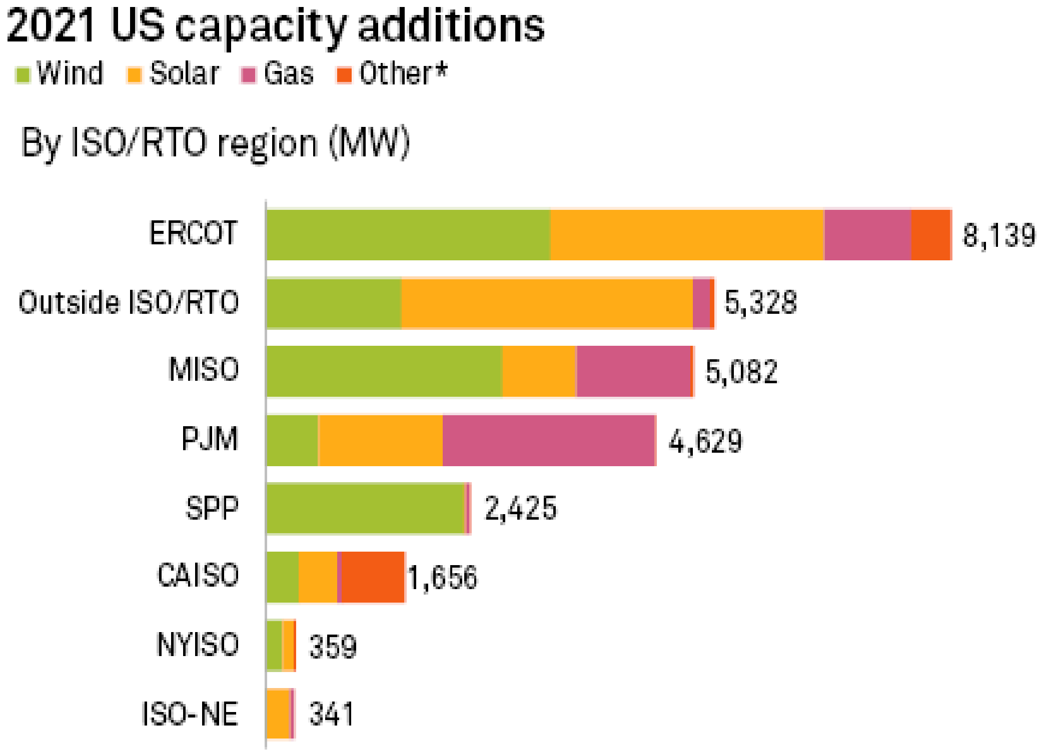
Generation Interconnection: 2021 Capacity Additions

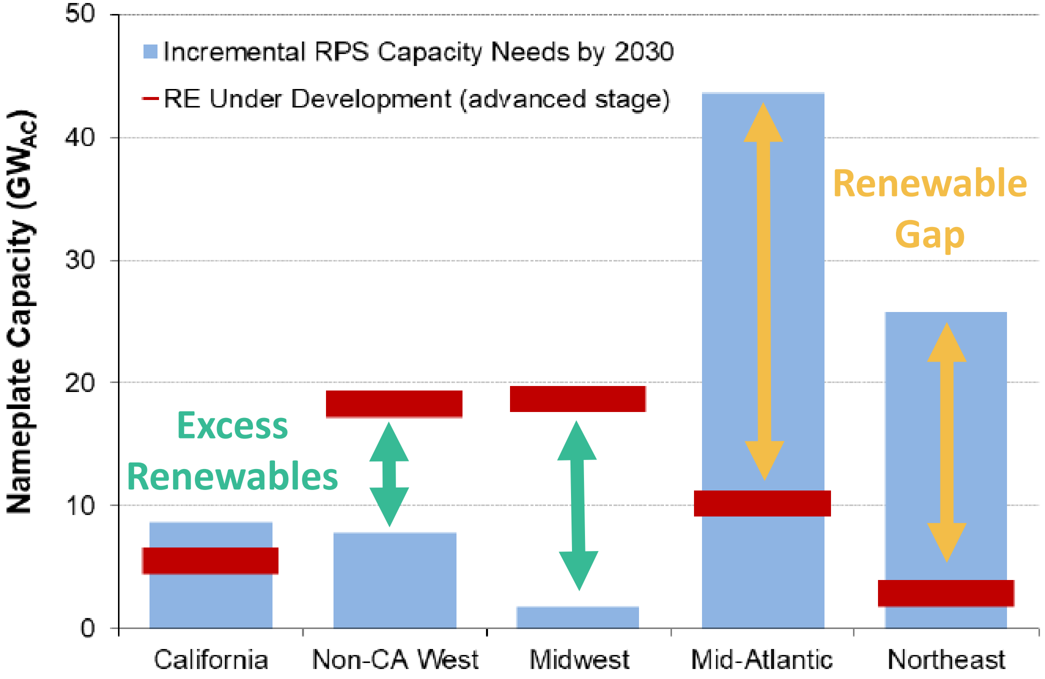
PJM, NYISO, and ISO-NE have interconnected significantly less renewable generation despite the regions' significant renewable development gap

RTO Size
80 GW
200 GW
150 GW
180 GW
95 GW
52 GW
42 GW
32 GW



Data compiled Jan. 11, 2022.
* Includes hydro, biomass, oil, geothermal and energy storage capacity.
Source: S&P Global Market Intelligence

Lawrence Berkeley National Lab
Estimated Renewables Development Gap



Source: Galen Barbose, "U.S. Renewables Portfolio Standards: 2021 Status Update (Early Release)," Lawrence Berkeley National Lab, Feb 2021. rps.lbl.gov

Substantial Differences in Generation Interconnection Processes

Generation interconnection processes and study criteria differ substantially across the regions:

- ERCOT's generation interconnection process is generally seen as more effective
  - Efficient handoff of study roles by ERCOT and Transmission Owners limits restudy needs
  - Projects can be developed and interconnected within 2-3 years; in other regions, the interconnection study process itself takes longer than that
  - Upgrades focused more on local needs (similar to ERIS) and are recovered through postage stamp
  - Network constraints managed through market dispatch – which imposes higher congestion and curtailment risks on interconnecting generators but yields more efficient outcomes and risk sharing
  - See working-paper.pdf (enelgreenpower.com) [Note: Brattle was not involved]
- Attractive: UK "Connect and Manage" (replaced prior "Invest and Connect")
  - Similar to ERIS; reduced lead times by 5 years; network constraints addressed later (e.g., with congestion management) https://www.gov.uk/guidance/electricity-network-delivery-and-access#connect-and-manage
- Generation interconnection study criteria matter, yet differ substantially across RTOs
  - PJM's stringent study criteria tend to trigger more "deep network" upgrades, which increases churn and restudy requirements; will often be less cost effective than congestion management

PJM’s 75 GW Renewable Generation Interconnection Study

Generation interconnection processes, studying one generator at a time, are ineffective in determining the most cost-effective transmission solutions. Pro-active planning is needed:

- For example: A review of PJM generation interconnection studies for 15.5 GW of individual offshore wind plants identified $6.4 billion in onshore transmission upgrades ($400/kW)
- In contrast: the recent PJM Offshore Wind Transmission Study that proactive evaluated all existing state public policy needs identified only **$3.2 billion in onshore upgrades for over 75 GW of renewable resources** (up to 17 GW of offshore wind, 14.5 GW of onshore wind, 45.6 GW of solar, and 7.2 GW of storage) ($40/kW)
- Upgrades also provide substantial PJM-wide economic benefits: reduced congestion, curtailments, emissions (App B)

State RPS Targets*

NJ: 50% by 2030**	VA: 100% by 2045/2050 (IOUs)
MD: 50% by 2030	NC: 12.5% by 2021 (IOUs)
DE: 40% by 2035	OH: 8.5% by 2026
DC: 100% by 2032	MI: 15% by 2021
PA: 18% by 2021***	IN: 10% by 2025***
IL: 25% by 2025/2026	

* RPS targets at time of study
** Includes an additional 2.5% of Class II resources each year
*** Includes non-renewable “alternative” energy resources

Table 10. Renewable Capacity in Model for Achieving State RPS Targets

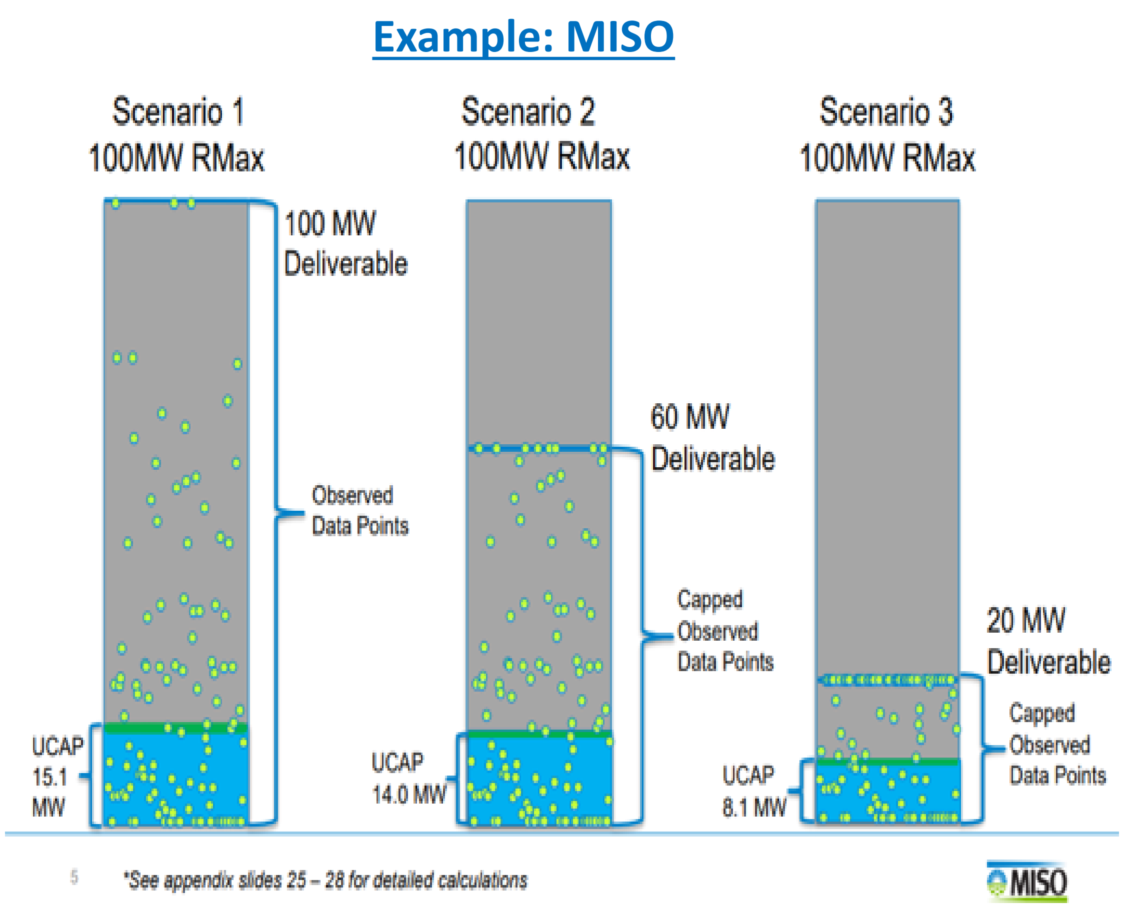
State	Year	Offshore Wind (MW)	Onshore Wind (MW)	Solar (MW)	Storage (MW)
NJ	2027	2,900	-	7,111	1,475
	2035	*7,648	-	11,322	2,875
MD	2027	768	210	5,002	-
	2035	1,568	210	5,602	-
DC	2027	-	-	343	-
	2035	-	-	462	-
DE	2027	-	-	468	-
	2035	-	-	595	-
VA	2027	2,600	130	6,270	280
	2035	5,200	130	16,570	3,100
NC	2027	-	600	1,117	-
	2035	-	600	1,153	-
PA	2035	-	1,585	2,185	58
IL		-	7,329	2,406	1,080
OH		-	1,742	3,938	24
MI		-	-	356	-
IN		-	2,325	275	-
Rest of PJM KY, TN, WV *(non-RPS states)*		-	609	713	54
2035 Total		14,416 MW	14,530 MW	45,577 MW	7,191 MW

Table 7. Scenario 4 Results

	<230 kV	230 & 345 kV	500 kV	Transformer	Upgrade Cost ($M)
Atlantic City Electric	$11.30	$27.60		$11.34	$50.24
American Electric Power	$33.50			$9.00	$42.50
Allegheny Power Systems (FirstEnergy)	$37.20				$37.20
Baltimore Gas & Electric	$27.60	$27.25	$173.50		$228.35
ComEd	$15.10	$38.40			$53.50
Dominion	$135.00	$557.40	$995.30	$191.00	$1,878.70
Delmarva Power	$35.20	$18.50			$53.70
Jersey Central Power & Light	$13.80	$15.90			$29.70
Met-Ed	$9.20	$5.20			$14.40
PECO		$75.60	$303.50	$50.00	$429.10
Penelec				$50.00	$50.00
Pepco		$0.70			$0.70
PPL		$12.15			$12.15
PSE&G		$332.90			$332.90
Total ($M)	$317.80	$1,111.60	$1,472.30	$311.34	$3,213.14

ELCC for Variable Resources

How to determine ELCC for energy delivered over non-firm/energy-only injection rights?



Source: [PowerPoint Presentation (misoenergy.org)]

- Several RTOs (MISO, PJM) are exploring how to determine the UCAP (capacity credits) of variable resources when only a portion of the transmission injection rights are "firm"
- It is reasonable that UCAP cannot exceed firm rights
  - But: by how much does energy delivered over non-firm transmission contribute to (or reduce) the ELCC of the resources?
- ELCC is a "probabilistic" concept; the availability of firm and non-firm transmission rights affects energy actually delivered
  - Firm transmission/injection rights tend to be 99.9% deliverable
  - Non-firm depend on location but may be >95% deliverable; can be determined easily based on historical or projected renewable energy curtailments
- It is not reasonable to assume zero energy will be delivered over non-firm rights
  - In PJM, curtailments on non-firm rights are rare (and small); and PJM's energy-only interconnection study criteria are very stringent (requiring significant transmission upgrades)

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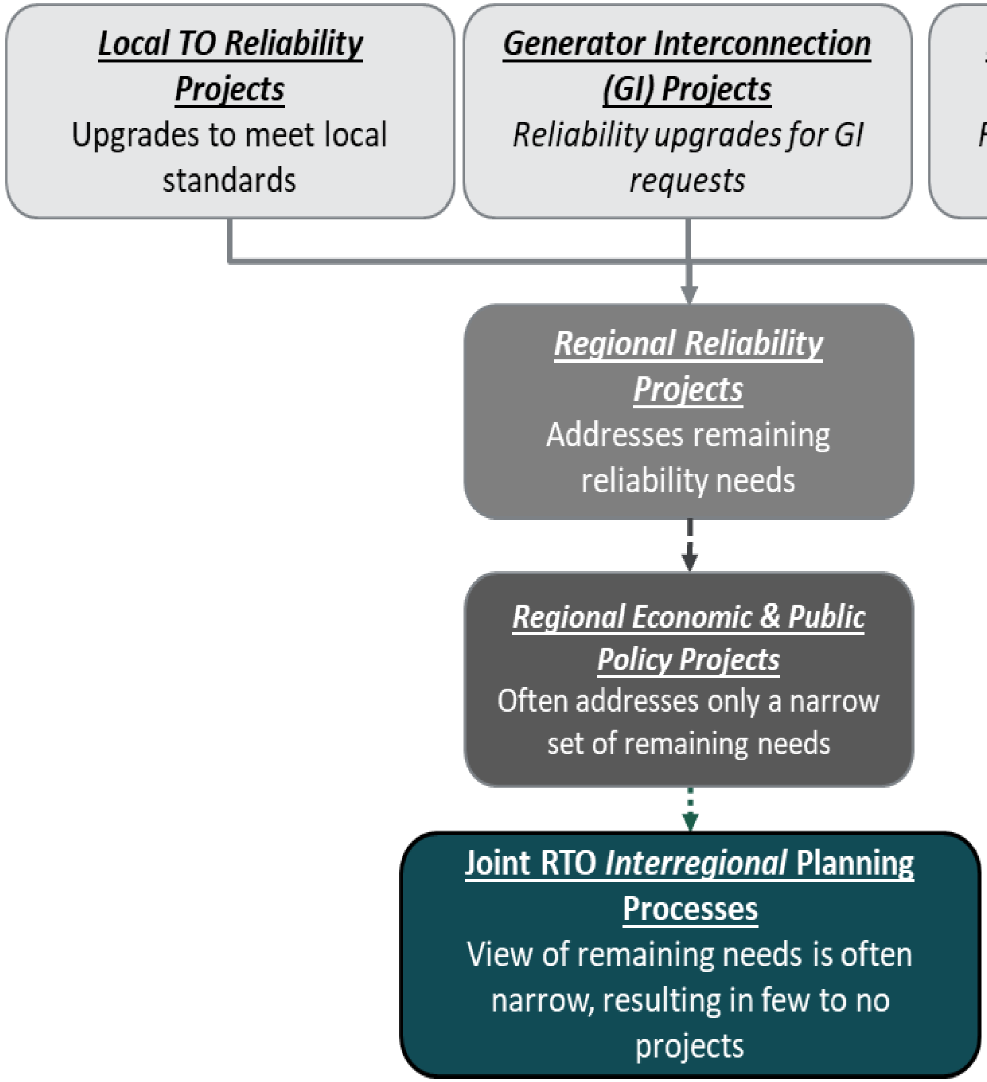
Johannes (Hannes) Pfeifenberger, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT's Center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

Current U.S. Transmission Planning Processes for…



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

Current U.S. Transmission Planning = Higher Total Costs

Current planning processes do not yield the most valuable transmission infrastructure and result in higher overall costs:

- Reactive, reliability-driven planning results in piecemeal, higher-cost transmission solutions
- Failure to evaluate multiple benefits of most transmission projects: does not result in the selection of the highest-value projects that reduce system-wide costs
- Failure to evaluate the full range of plausible futures (to explicitly account for long-term uncertainties): results in higher-cost outcomes when the future deviates from base case planning assumptions, which usually are based on "business-as-usual" or "current-trends" forecast
- Failure to consider interregional transmission solutions: result in higher-cost regional and local transmission investments

More pro-active, multi-value, and scenario-based transmission planning processes are needed, as discussed in:

- 21st Century Transmission Planning: Benefits Quantification and Cost Allocation (presentation)
- Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs (report)
- A Roadmap to Improved Interregional Transmission Planning (report)

Additional Reading on Transmission

Pfeifenberger, 21st Century Transmission Planning: Benefits Quantification and Cost Allocation, Prepared for the NARUC members of the Joint Federal-State Task Force on Electric Transmission, January 19,2022.

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

Pfeifenberger, Transmission–The Great Enabler: Recognizing Multiple Benefits in Transmission Planning, ESIG, October 28, 2021.

Pfeifenberger et al., Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, Brattle-Grid Strategies, October 2021.

Pfeifenberger, Transmission Options for Offshore Wind Generation, NYSERDA webinar, May 12, 2021.

Pfeifenberger, Transmission Planning and Benefit-Cost Analyses, presentation to FERC Staff, April 29, 2021.

Pfeifenberger et al., Initial Report on the New York Power Grid Study, prepared for NYPSC, January 19, 2021.

Pfeifenberger, "Transmission Cost Allocation: Principles, Methodologies, and Recommendations," prepared for OMS, Nov 16, 2020.

Pfeifenberger, Ruiz, Van Horn, "The Value of Diversifying Uncertain Renewable Generation through the Transmission System," BU-ISE, October 14, 2020.

Pfeifenberger, Newell, Graf and Spokas, "Offshore Wind Transmission: An Analysis of Options for New York", prepared for Anbaric, August 2020.

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Tsuchida and Ruiz, "Innovation in Transmission Operation with Advanced Technologies," T&D World, December 19, 2019.

Pfeifenberger, "Cost Savings Offered by Competition in Electric Transmission," Power Markets Today Webinar, December 11, 2019.

Pfeifenberger, "Improving Transmission Planning: Benefits, Risks, and Cost Allocation," MGA-OMS Ninth Annual Transmission Summit, Nov 6, 2019.

Chang, Pfeifenberger, Sheilendranath, Hagerty, Levin, and Jiang, "Cost Savings Offered by Competition in Electric Transmission: Experience to Date and the Potential for Additional Customer Value," April 2019. "Response to Concentric Energy Advisors' Report on Competitive Transmission," August 2019.

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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.

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

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

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

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

Brattle Group Practices and Industries

ENERGY & UTILITIES

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

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- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
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- White Collar Investigations & Litigation

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