Reducing Energy Costs and Risks with Advanced Transmission Technologies

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PREPARED FOR

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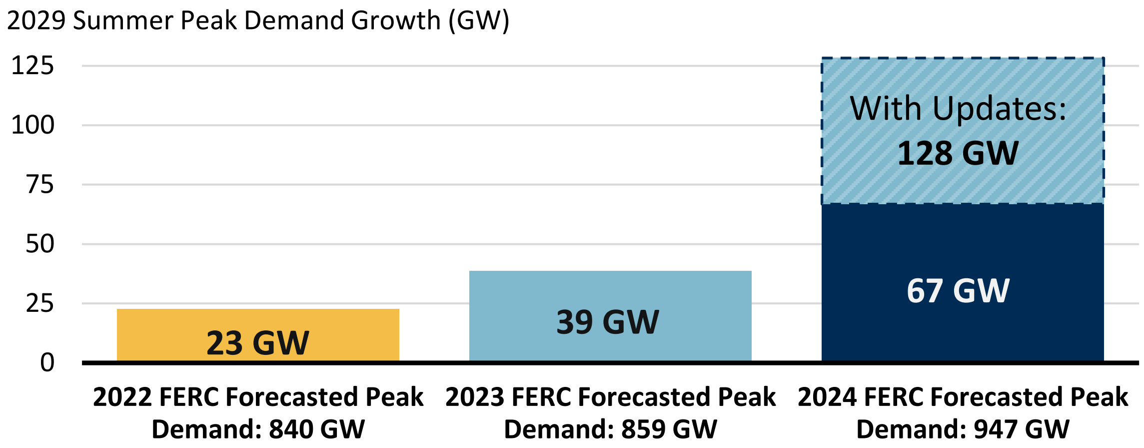
Transmission Needs

Various studies indicate the need for a massive expansion of the electric transmission grid, with estimates suggesting that transmission capacity must double or triple in the coming decades. This seismic shifts needs to be done at an accelerated pace to fulfill near-term grid demand.

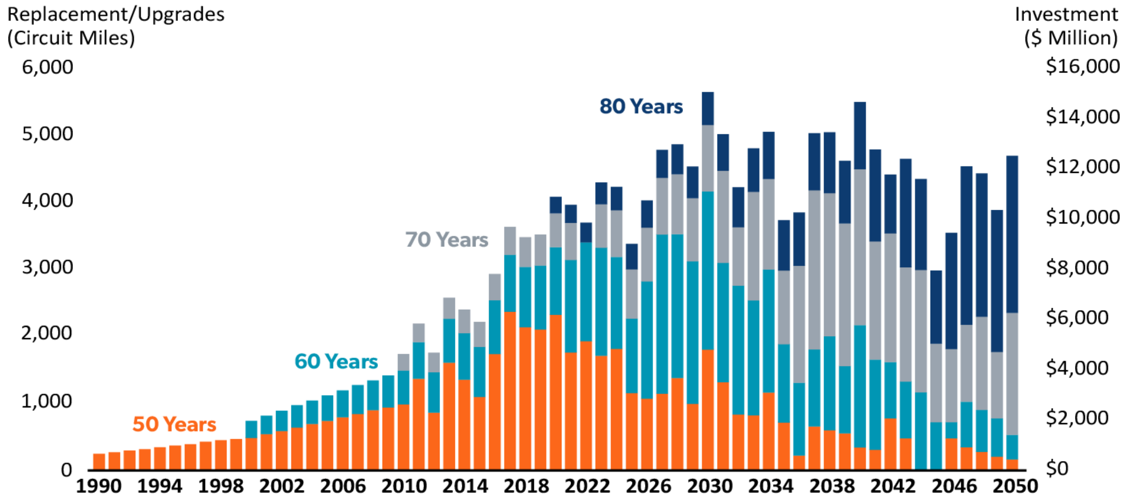
Estimated Transmission Congestion Costs ($ Million)

	2016	2017	2018	2019	2020	2021	2022	2023
ERCOT	497	976	1,260	1,260	1,400	2,100	2,800	2,400
ISO-NE	39	41	65	33	29	50	51	32
MISO	1,402	1,518	1,409	934	1,181	2,849	3,700	1,800
NYISO	529	481	596	433	297	551	1,000	311
PJM	1,024	698	1,310	583	529	995	2,500	1,068
SPP	280	500	450	457	442	1,200	2,000	1,400
CAISO	197	138	745	451	605	760	1,323	1,049
TOTAL	**3,968**	**4,352**	**5,835**	**4,151**	**4,483**	**8,505**	**13,374**	**8,060**

Projected Load Growth by Summer 2029



Estimated US Aging-Asset Refurbishment Needs



Addressing Transmission Needs

The two ways to increase transmission – through Generation Interconnection (GI) and long-term system planning — both facilitate additional renewable buildouts.

There is a gap between GI and long-term planning in both the study objective and timeline.

- GI study objectives are to identify *least-cost* upgrades needed to provide generator interconnection. GI studies make use of reliability analysis, focusing *over the next 5 years*.
- Long-term planning studies aim to identify options with the *largest net benefits* looking at *longer time periods (e.g., 20 years).*

The industry recognizes this gap and are trying to align the transmission planning and GI studies.

- FERC Order 2023 addresses GI.
- FERC Order 1920 addresses regional transmission planning and cost allocation.

For investor-owned utilities (IOUs), profit incentive is based on return on invested assets (rate base).

- Higher-cost investments lead to larger profits.
- FERC governs interstate commerce (e.g., wholesale markets and transmission) while states govern retail markets and local siting.

Transmission rate designs are largely based on capacity reserved (MW) rather than power delivered (MWh).

FERC Order 1920

Requires Transmission Providers to develop long-term transmission plans.

Develop at least three plausible and diverse scenarios to identify long-term transmission needs and candidate solutions.

Quantify benefits of candidate solutions, and establish evaluation and selection criteria that, among other requirements, identifies the preferred solution(s) that "maximizes benefits accounting for costs over time without over-building transmission facilities."

Transmission Providers must consider *alternative transmission technologies* (see next slide).

Transmission providers must quantify at least *seven reliability and economic benefits* for all candidate solutions or the portfolio as a whole.

1. Avoided / deferred transmission & aging infrastructure investments
2. Loss of load probability and reduced planning reserve margins
3. Production cost savings
4. Reduced transmission losses
5. Reduced congestion due to transmission outages
6. Mitigation of extreme weather
7. Capacity cost benefits from reduced peak energy losses

Alternative Transmission Technologies

Alternative Transmission Technologies (ATTs) include certain Grid Enhancing Technologies (GETs) and High-Performance Conductors (HPCs):

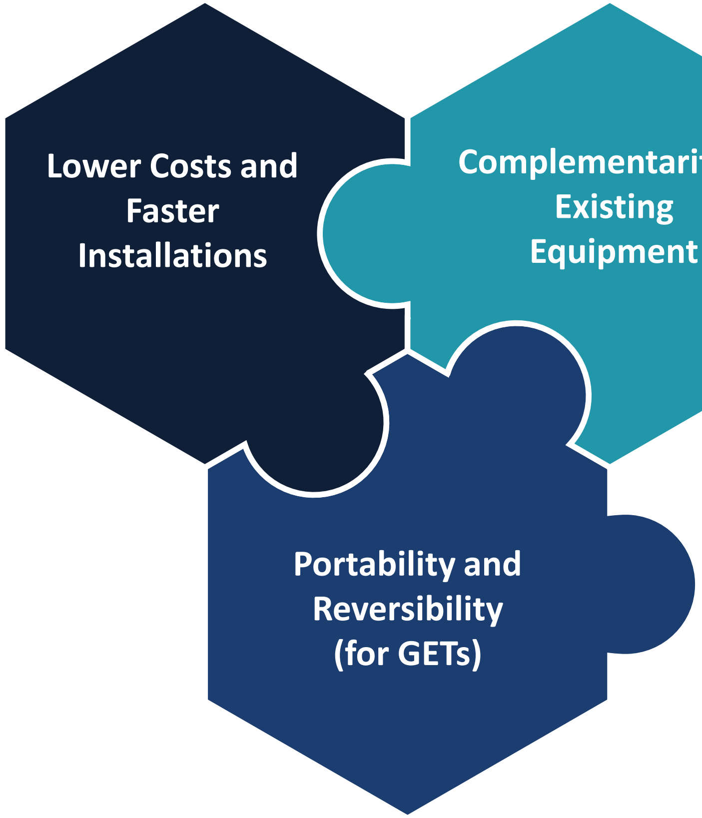
Order 1920 identifies three specific GETs (and Order 1920-A confirms that transmission providers could consider other GETs as well).

1. Dynamic Line Ratings (DLR)
2. Advanced Power Flow Control
3. Transmission Switching

Order 1920 recognizes six different types of HPCs.

- HPCs are defined as advanced transmission conductors engineered to carry higher power loads (1.5x) with reduced thermal sag, improved efficiency (i.e., lower losses), and greater resilience (compared to traditional conductors).
- HPCs often use carbon and/or composite cores (or advanced steel cores), instead of the traditional steel wire cores used for conventional conductors.

Key Characteristics of ATTs



Seven Benefits and ATTs

Case Study #	Technology	Benefits						
		1	2	3	4	5	6	7
1: DNV-GL PJM Study	APFC	x		x				
2: DOE Lift-off Report	GETs	x						
3: SCE HPC and Transmission Towers	HPC	x						
4: NY DLR	DLR	x						
5: DOE GETs Report	DLR, APFC	x						
6: 2018 "Bomb Cyclone" and DLR	DLR (AAR)		x				x	
7: SPP Winter Storm Jupiter	TS		x				x	
8: SPP Winter Storm Elliot	TS		x				x	
9: HPC Design and History	HPC						x	
10: Brattle SPP GETs Study	DLR, TS, APFC			x	x			
11: RMI PJM GETs Study	DLR, TS, APFC			x				
12: Transmission Switching Studies	TS			x			x	x
13: GRE DLR	DLR			x				
14: ELIA DLR	DLR			x				
15: Hydro Quebec Conductors Comparison	HPC				x			
16: APFC 2015	APFC					x		
17: EPM and AFC	APFC					x		
18: Transmission Switching Study	TS					x		
19: PJM Winter Storm Elliot	DLR						x	
20: Nevada Energy HPC	HPC						x	
21: Oklahoma Gas and Electric HPC	HPC						x	
22: California Wildfire and HPC	HPC						x	
23: Canada Icing and HPC	HPC						x	
24: Southeastern U.S. and HPC	HPC						x	
25: New York Phase Angle Regulators	APFC, TS							x

Barriers for Deploying ATTs

ATTs can provide all *Seven Benefits* (and beyond).

The Case Studies highlight the complexity and difficulty in assessing the benefits of ATTs.

Several existing barriers are also preventing ATTs from being deployed widely:

- Insufficient recognition of the ATTs themselves;
- Misaligned incentives;
- The use of traditional planning approaches that tend to be static and deterministic; and
- The perceived lack of standardized data, tools, and analysis methodologies, along with human resources.

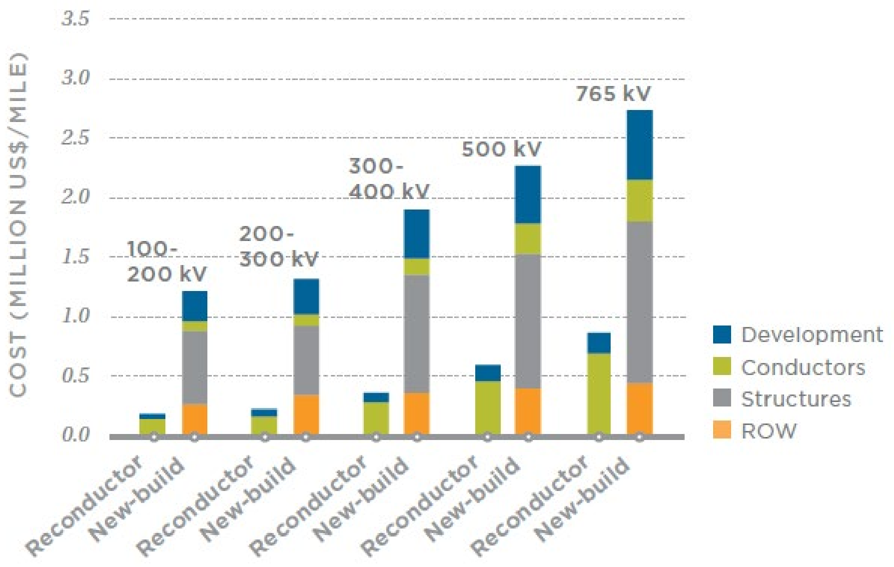
Benefits of ATTs (Reconductoring with HPCs)

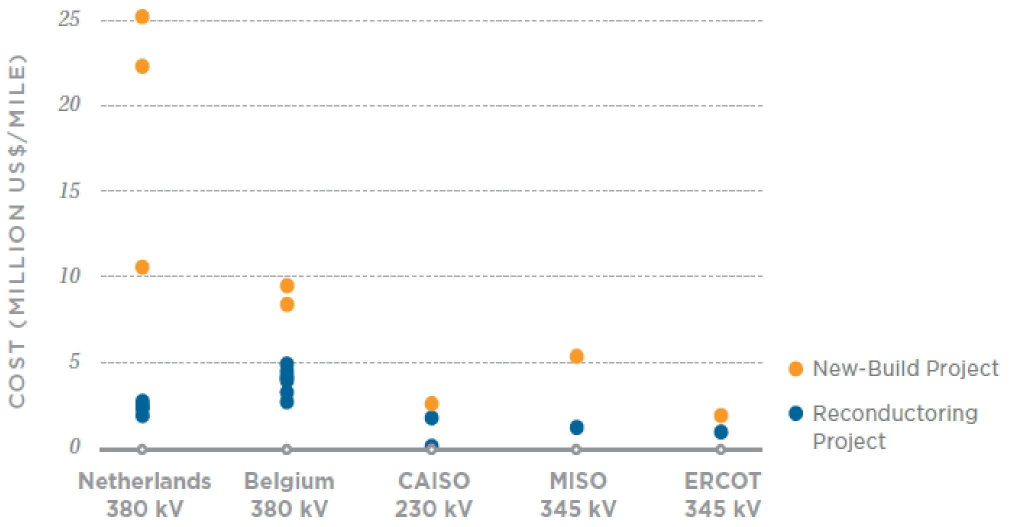
High-Performance Conductors (HPCs) can increase path transfer capability at lower cost and faster installation:

Many applications of HPCs today are reconductoring existing paths.

- Costs of reconductoring with HPCs are estimated to be around half of building new lines.
- Reconductoring with HPCs can be completed in 18 to 36 months (compared to 5 to 10 years or more for developing a new path).

Cost Comparison between Reconductoring and New Builds of Transmission





Source: GridLab, 2035 and Beyond –Reconductoring Report, available at: https://www.2035report.com/wp-content/uploads/2024/04/GridLab_2035-Reconductoring-Technical-Report.pdf

Benefits of ATTs (GETs vs Traditional Wires-Based Solutions)

Grid-Enhancing Technologies (GETs) can increase path transfer capability faster, at lower cost, and with less uncertainty

Additional Benefits (beyond the *Seven*) :

- **Cost certainty.**
  - Total cost of DLR is less than the per-mile cost range of rebuilding.
- **Scheduling certainty.**
  - Total time to implement DLR is less than the range of rebuilding (and equal to that of reconductoring).
  - There are no outages required for installing DLR.
- **Buying Time**
  - Low cost and reversibility allows for low-regrets investments that can buy time before decisions for larger investments are made.

Potential Solution Comparisons for Harwood to Susquehanna 230 kV Path

	 Reconductor	 Rebuild	 Dynamic Line Rating
Time to Implement	2-3 Years	3-5 Years	~1 Year
Downtime	Extended Outages	Extended Outages	No Outages
Cost	$0.5 Million per mile	$2-3 Million per mile	<$50 Thousand per mile*
Est. Capacity Benefit	+34%	+106%	+10-30%

*<$1 Million total cost on 20-mile line & longers lines are cheaper

Relevant State Entities

Relevant State Entities (RSEs) are defined as any state entity responsible for electric utility regulation or siting electricity transmission, or another entity designated by state law.

RSEs play an essential role in helping transmission providers navigate complexities, realize the full potential of ATTs, and accelerate the industry transition.

- Order 1920 requires transmission providers to consult with RSEs when developing evaluation processes and selection criteria.
- RSEs could request transmission providers consider a reasonable number of additional scenarios that include ATTs.
- RSEs could also advocate for the inclusion or omission of certain selection criteria – such as removing qualitative criteria that would bias the selection process against ATTs – without considering benefit-to-cost ratios.

Relevant State Entities (continued)

Relevant State Entities (RSEs) are defined as any state entity responsible for electric utility regulation or siting electricity transmission, or another entity designated by state law.

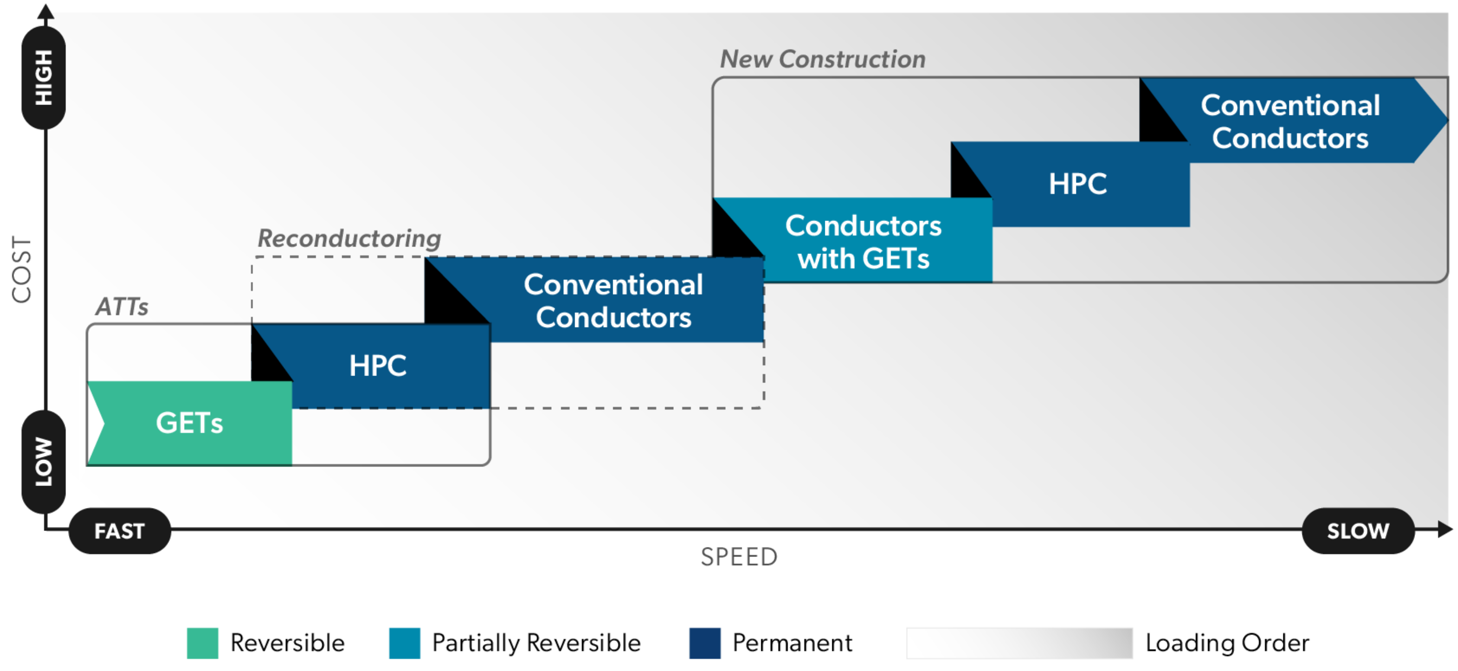
These actions could help RSEs establish a preferred loading order for transmission solution selection that aligns with state priorities (see next slide).

- Options could include a “rule of thumb” in evaluating the potential solutions at a high level.
- An example may be prioritizing GETs for transfer increase needs of 20% or less and HPCs for transfer increase needs of 50% or more or when “right-sizing” opportunities are observed.
- A time or schedule-based approach, such as prioritizing GETs for immediate needs, may also be viable.
- A pre-screening cost threshold based on a potential solution’s likelihood of producing certain monetizable *Benefits*, by analyzing past transmission projects together with wholesale energy market data (where such data exists) ahead of time may also be an option.

Potential Loading Order

Ultimately, the success of Order 1920 will depend on the willingness of transmission providers to embrace these innovative solutions, modernize their frameworks, and deliver a grid development plan that is reliable, efficient, and ready for the future. Active, collaborative engagement from RSEs – combined with their guidance to ensure accountability for transmission providers – will be essential for achieving success.

Illustrative Loading Order



Discussion

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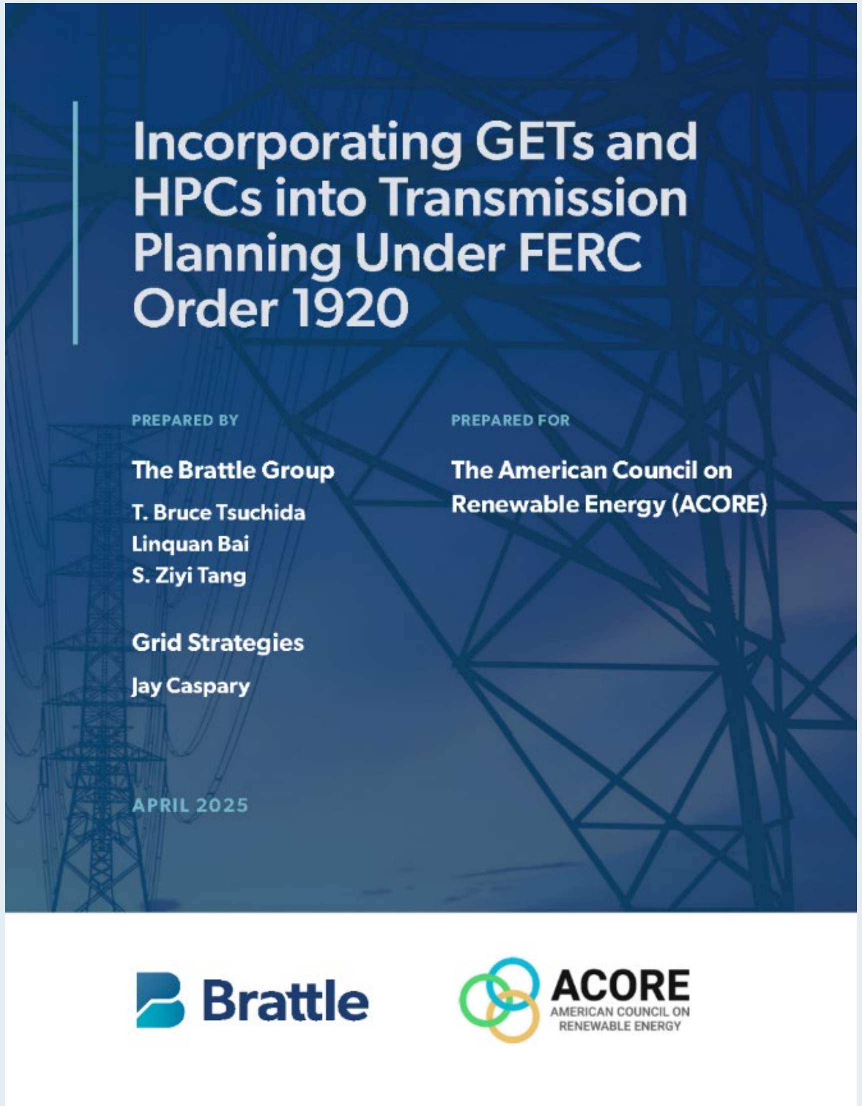
Incorporating GETs and HPCs into Transmission Planning Under FERC Order 1920

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Mr. T. Bruce Tsuchidais a Principal of The Brattle Group with over thirty years of experience in domestic and international power generation development, utility operation, and power market analysis.

He specializes in bridging technology, economics, and regulatory policy, particularly in assessing the impact of new technologies and regulatory changes. This includes modeling of evolving wholesale and retail electricity markets, impact of renewables, storage, and other new technologies' on system operations, utility business, and various valuations (including the engineering and technical capabilities) of transmission, generation, and distribution assets, deliverability, and contracts.

Prior to joining Brattle, Mr. Tsuchida was a Principal at Charles River Associates, and previously a Project Manager at the Tokyo Electric Power Company where he oversaw international generation development projects and was the lead engineer for Southeast Asia generation units.

Mr. Tsuchida earned his M.S. in Technology and Policy, and M.S. in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology in Cambridge, Massachusetts, and a B.S. in Mechanical Engineering from Waseda University in Tokyo, Japan.

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