Energy Storage Value for New York

PRESENTED AT:

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THE Brattle GROUP

Industry Trends Favor Storage

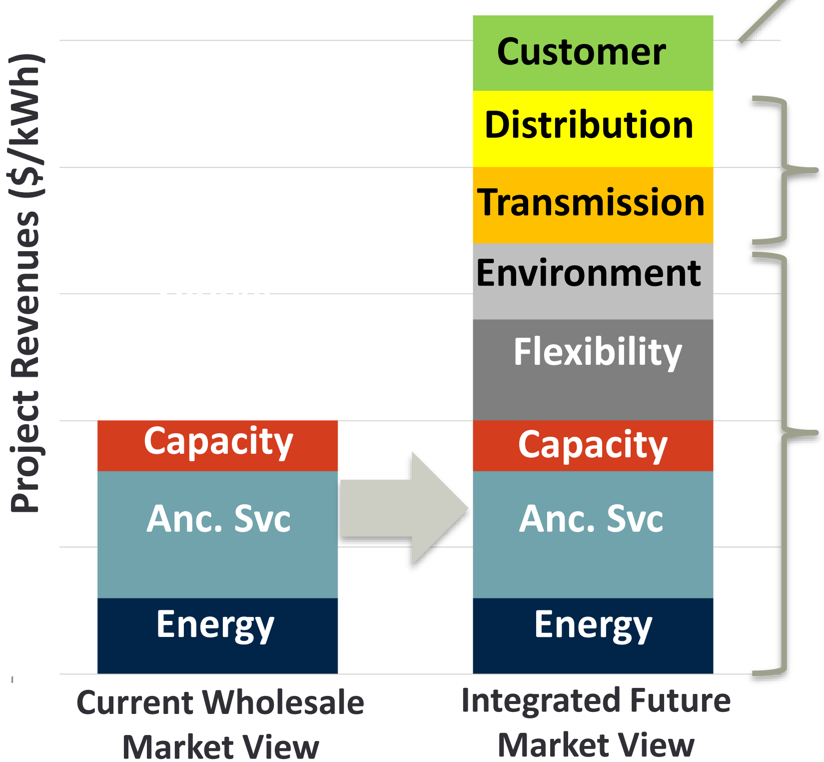
- **Continued storage cost reductions and technology improvements**. Some applications already cost-effective today, but as costs fall further storage will be transformative.
- **Retail customers are focused on cost reduction and control,** including interest in participating in the marketplace through Distributed Energy Resources
- **Focus on the "Value Aggregation"** and recognition of storage's multiple uses and values throughout the delivery chain
- **Innovative business models** that maximize storage's overall value
- **Aggressive decarbonization goals in some regions** with electrification and the potential that storage will enable low carbon systems
- **Growing need for system flexibility** due to variable generation and load

Storage is integral to the future power system.

Battery Storage Value Streams

Maximizing storage's potential requires capturing multiple value streams. New regulatory frameworks are needed.

Storage Value Components



Customers

- Increased reliability (reduced outages)
- Increased engagement in power supply
- Retail bill savings

Utility Infrastructure

- Deferred or avoided investments in distribution and transmission infrastructure

Wholesale Markets

- Traditional value drivers: energy arbitrage, fast-response capabilities, and avoided capacity
- Realizing additional value due to higher quality ancillary services
- Flexibility and clean-energy products will provide additional revenue opportunities in the future

FERC Order 841: Addressing Wholesale Market Barriers

Order 841 will help storage compete to provide wholesale services on a level playing field with other technologies

Requires RTOs to establish a participation model that must:

- Ensure participating resources are eligible to provide **all capacity, energy, and ancillary services** the resource is technically capable to provide
- Execute all storage wholesale transactions **at locational marginal price**
- Ensure resource **can be dispatched and set the wholesale price**
- **Recognize physical and operational characteristics** of storage
- Establish a **minimum size requirement** that does not exceed 100 kW
- **Allow storage to de-rate capacity** to meet minimum run-time requirements

Respondents were generally supportive

- Noted their appreciation for FERC addressing storage's wholesale barriers
- RTOs noted their appreciation for the Order's implementation flexibility (some requests clarifications)

Source: 162 FERC ¶ 61,127. *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*. February 15, 2018.

Order 841: Stakeholders' Responses

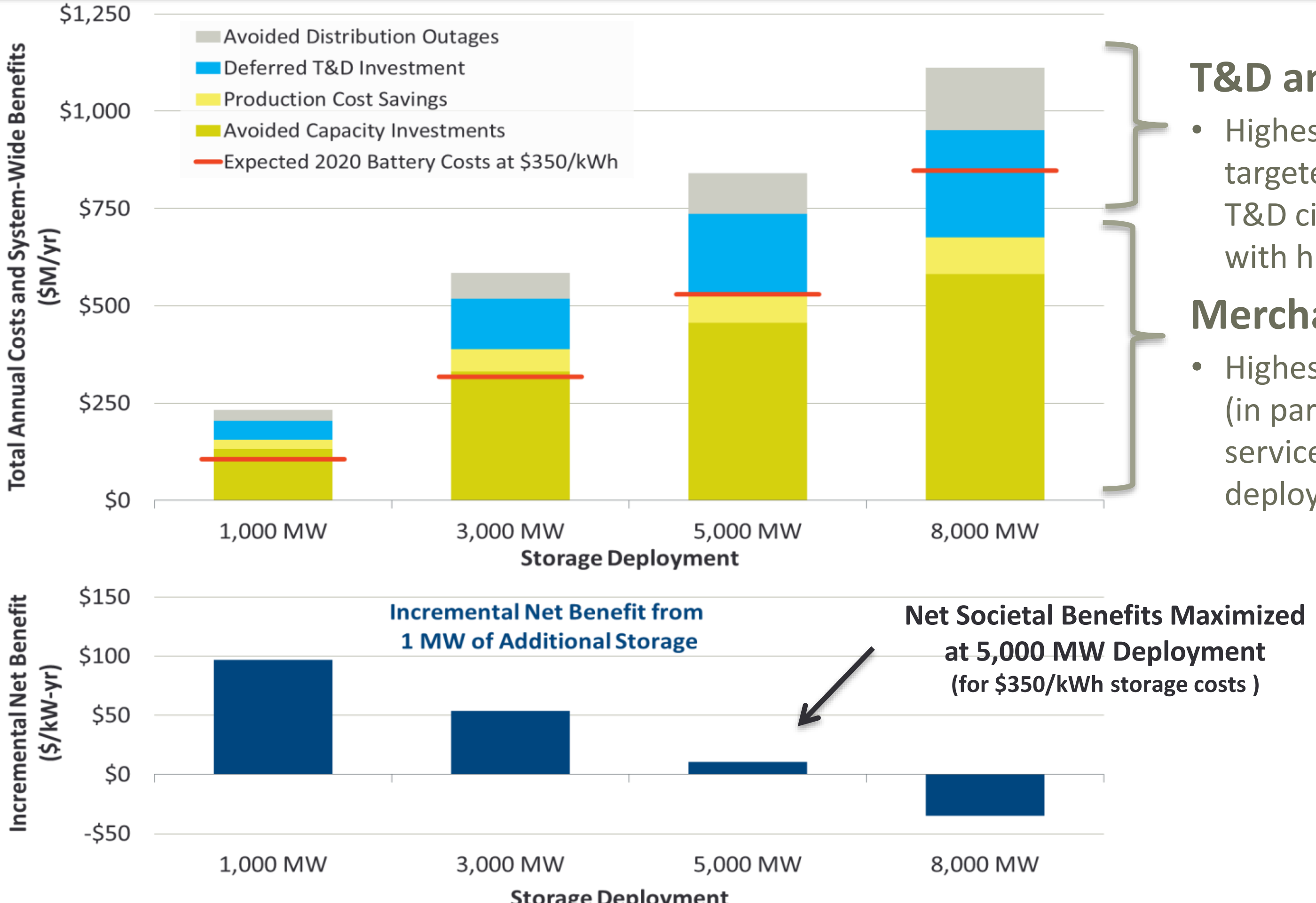
Stakeholders have already raised many questions in response to Order 841. A few have raised important regulatory questions, including:

- **Transmission charges** for energy used in charging storage
- **Interactions between federal and state** oversight of distributed energy storage
- **Jurisdiction over behind-the-meter storage** used for both retail and wholesale purposes
- **Responsibilities for ensuring distribution-level reliability** when distribution-connected storage's participation in wholesale markets has implications for the distribution system
- **Metering requirements for behind-the-meter storage** participating in wholesale market

Resolving jurisdictional and control issues will be important to unlocking the full potential for storage's value proposition.

ERCOT Findings: System-Wide Benefits

Incremental system-wide benefits exceed incremental costs for up to 5,000 MW. ~40% of benefits from T&D deferral and improved reliability.



T&D and Customer Value

- Highest value opportunities if targeted to underperforming T&D circuits and customers with high outage costs

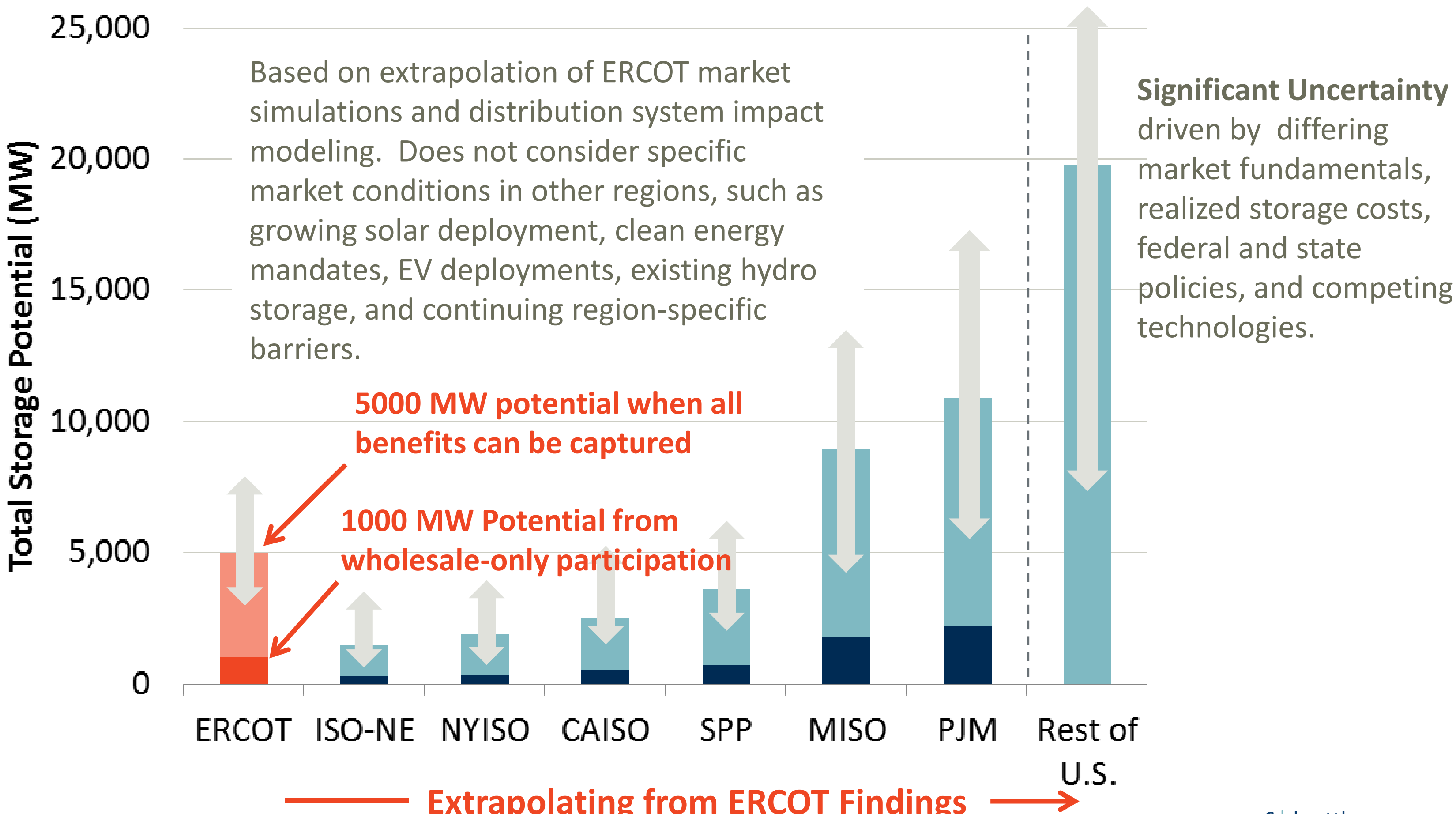
Merchant Value

- Highest-value opportunities (in particular ancillary services) saturate quickly as deployments rise

Source: Chang, et al., The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments, Prepared for Oncor, March 2015. Based on analysis with Brattle's bSTORE modeling platform.

U.S.-Wide Storage Potential

At a cost of $350/kWh (installed), Order 841 could unlock 7,000 MW based solely on wholesale-market participation in RTOs. This increases to 50,000 MW US-wide if all benefits can be captured, but requires states to unlock T&D and customer benefits.



Notes: Extrapolated from ERCOT study based on average 2016 system load

The Value of Storage in New York

Storage may have greater value in New York than in other systems

Value Stream	Value in New York
Energy	• Price volatility greatest downstate
Avoided capacity costs	• Highest downstate (NYC's summer 2017 prices of $10.4/kW-month)
Ancillary services and flexibility value	• Increasing due to growing renewables • NYISO investigating flexible ramp product
Emissions Reduction	• Potentially reduce ozone-contributing pollutants from peaking units • Potentially valued through NYISO's proposed carbon pricing • NYC residual oil elimination
Deferred transmission costs	• Ongoing challenge of increasing upstate -> downstate flows
Deferred distribution costs	• Demonstrated through BQDM project
Improved reliability	• Distributed storage to improve reliability and resilience, inc'l in NYC

- NY-BEST recommended goal of 2,000 MW storage by 2025 and 4,000 MW by 2030
- In January 2018, Governor Cuomo announced a storage target of 1,500 MW by 2025
- A 2030 energy storage goal to be established by the Public Service Commission

Sources:

NY-BEST Energy Storage Roadmap, January 2016
Governor Cuomo Unveils 20th Proposal of 2018 State of the State: New York's Clean Energy Jobs and Climate Agenda, January 2018
NYISO 2018 capacity prices: 2018 Summer Strip; Ethan Avallone, NYISO. Market Design Concepts to Prepare for Significant Renewable Generation. April 2018.

Opportunities for Energy Storage in New York

New York is viewed as a leading state in setting policies favorable to storage

Retail Market Activities: Multiple ongoing proceedings

- **REV proceeding** views role of utility transforming to a distributed system platform (DSP) that facilitates deployment of distributed resources by 3rd parties (utilities generally cannot own DERs)
- **VDER rate** compensates DERs (including those paired with storage) based on avoided costs, including location and environmental impacts
- **PSC** has ordered utilities to deploy at least two projects by end of 2018 that perform at least two grid functions
- **BQDM** involved DERs, including storage, to defer expensive distribution upgrade

Wholesale Market Activities: NYISO incorporating storage into the wholesale market

- **NYISO's** State of Storage report outlines roadmap for Energy Storage Resource (ESR) participation
- **ESR participation model** seems to be consistent with FERC Order 841, e.g. storage co-optimized across all services, offers reflect storage's physical constraints, storage can set LBMP
- **Active stakeholder process** through Market Issues Working Group

Dual participation across retail and wholesale: Rules under development

- Recognized in NYISO Distributed Energy Resources roadmap
- NYISO actively working with Joint Utilities

Accessibility of Value Streams in New York

Value Stream	Value Stream Available if Located Behind-the-Meter?	Front-of-the-Meter	
		Value Stream Available if Located on the Distribution System?	Value Stream Available if Located on the Transmission System?
Customer Demand Charge Reduction	Yes	No	No
Energy Arbitrage	Yes	Yes	Yes
Utility Demand Response Programs[1]	Yes	Limited[2]	No
Con Ed Demand Management Program	Yes	No	No
NYISO Demand Response	Yes	Limited[3]	Limited[2]
NYISO ICAP	Limited[4]	Limited[4]	Yes
NYISO Frequency Regulation	Limited[4]	Limited[4]	Yes
NYISO Reserves	Limited[4]	Limited[4]	Yes
NYISO VVO	Limited[4]	Limited[4]	Yes
NWA	Yes	Yes	No
Emergency Power	Yes	Limited[5]	No
NYSERDA Programs	Yes	Yes	No
VDER	Yes[5]	Yes[6]	No
Hosting Capacity	TBD	Yes	No
EV Integration	TBD	TBD	TBD

Source: NY-BEST, Energy Storage Guide, March 2018.

1 Another option for FTM systems focusing on utility DR would be to participate in Con Ed's SC-11 Buyback which permits systems to export energy onto the grid, receiving wholesale LMP for the energy produced. Unfortunately, this is not economic, since the retail rates are higher than their wholesale counterparts, resulting in a negative value stream in most cases.

2 The system would need to be connected such that it could charge from the grid, and provide DR on the system's baseline load. Since it is for a FTM system, there is no load other than the battery system itself and the compensation through DR will not be significantly more than the cost of charging the system through retail rates.

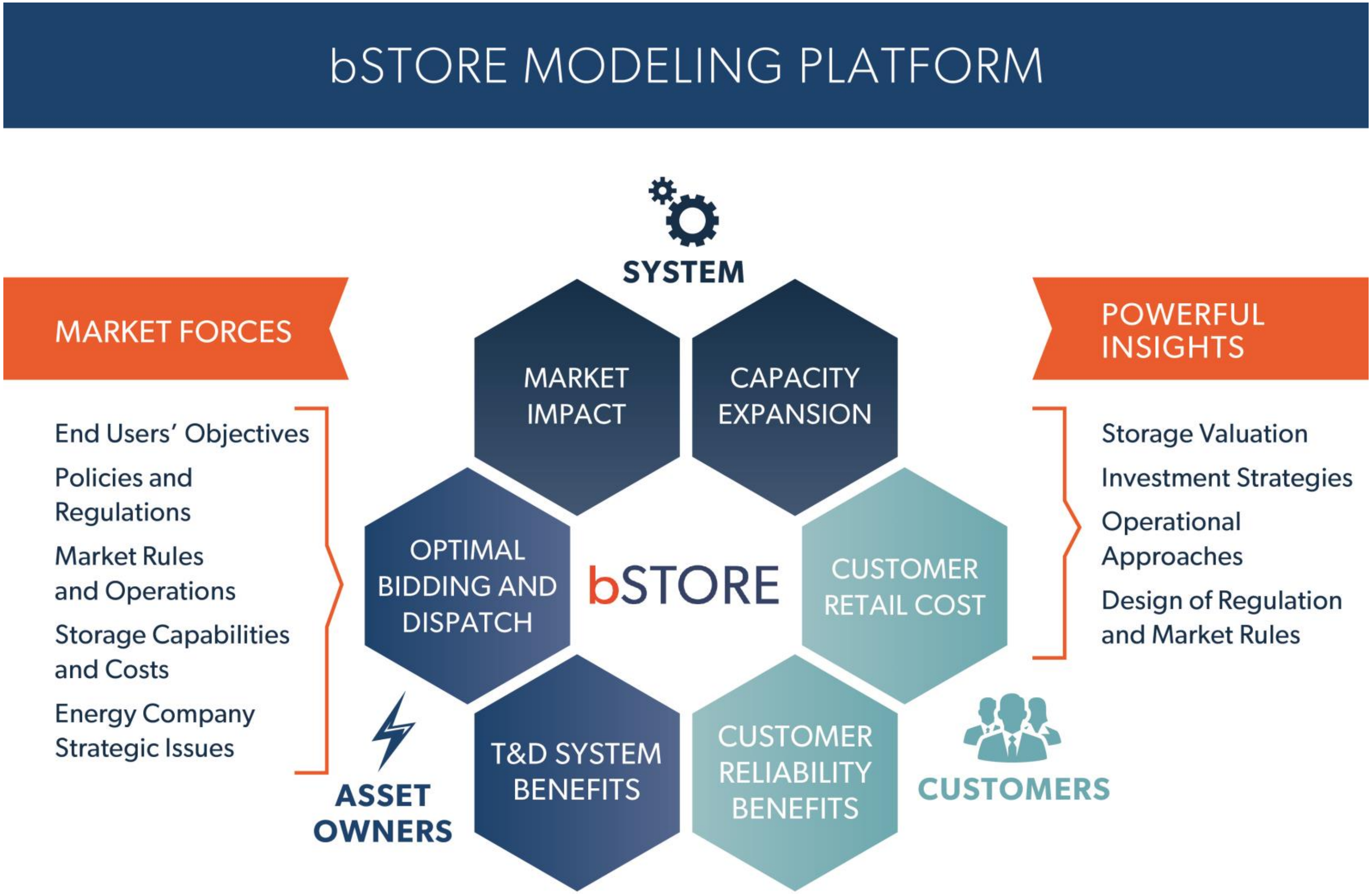
3 The system would be limited by its capacity, and likely need to be aggregated in order to meet the requirements of NYISO demand response programs. Since it is for a FTM system, there is no load other than the battery system itself and the compensation through DR will not be significantly more than the cost of charging the system through retail rates.

4 The system would have to receive approval from the NYISO, have adequate capacity, and be arranged so it could export energy onto the grid. Please see the dual participation section for more information.

5 The system would need to be part of a utility-level microgrid, where it could power a limited number of critical facilities or buildings.

6 The system would need to be co-located with solar or other distributed generating resources

Assessing Multiple Value Streams



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Additional Reading

"Getting to 50 GW? The Role of FERC Order 841, RTOs, States, and Utilities in Unlocking Storage's Potential," Presented at the Energy Storage Association Annual Conference, April 18, 2018

"Battery Storage Development: Regulatory and Market Environments," Michael Hagerty and Judy Chang, Presented to the Philadelphia Area Municipal Analyst Society, January 18, 2018

"U.S. Federal and State Regulations: Opportunities and Challenges for Electricity Storage," Romkaew P. Broehm, Presented at BIT Congress, Inc.'s 7th World Congress of Smart Energy, November 2, 2017

"Stacked Benefits: Comprehensively Valuing Battery Storage in California," Ryan Hledik, Roger Lueken, Colin McIntyre, and Heidi Bishop, Prepared for Eos Energy Storage, September 12, 2017

"The Hidden Battery: Opportunities in Electric Water Heating," Ryan Hledik, Judy Chang, and Roger Lueken, Prepared for the National Rural Electric Cooperative Association (NRECA), the Natural Resources Defense Council (NRDC), and the Peak Load Management Alliance (PLMA), February 10, 2016

"Impacts of Distributed Storage on Electricity Markets, Utility Operations, and Customers," Johannes P. Pfeifenberger, Judy Chang, Kathleen Spees, and Matthew Davis, Presented at the 2015 MIT Energy Initiative Associate Member Symposium, May 1, 2015

"The Value of Distributed Electricity Storage in Texas - Proposed Policy for Enabling Grid-Integrated Storage Investments," Judy Chang, Johannes P. Pfeifenberger, Kathleen Spees, Matthew Davis, Ioanna Karkatsouli, James Mashal, and Lauren Regan, Prepared for Oncor, March 2015

Brattle's Storage Experience

Asset Valuation	• Valuing and sizing renewables + storage facilities • Valuing storage across multiple value streams • Developing bid/offer strategies to maximize value • Accommodating storage into IRPs • Supporting due diligence efforts of investors
Market Intelligence	• The state and federal policy landscape • Electricity market fundamentals and opportunities • Storage cost and technology trends • Current and emerging business models
Policy, Regulatory, and Market Design	• Wholesale market design • Market and regulatory barriers • Utility ownership and operation models • Retail rate implications of distributed storage • Implications of storage on wholesale markets

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About The Brattle Group

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