Getting to 50 GW?

The Role of FERC Order 841, RTOs, States, and Utilities in Unlocking Storage's Potential

PRESENTED AT:

Energy Storage Association Annual Conference

Boston

PREPARED BY

Judy Chang

Roger Lueken

Hannes Pfeifenberger

Pablo Ruiz

Heidi Bishop

April 18, 2018

THE Brattle GROUP

Agenda

- The Storage Value Proposition
- FERC Order 841
- Getting to 50 GW Storage Potential
- Significant Roles for States

Industry Trends Favor Storage

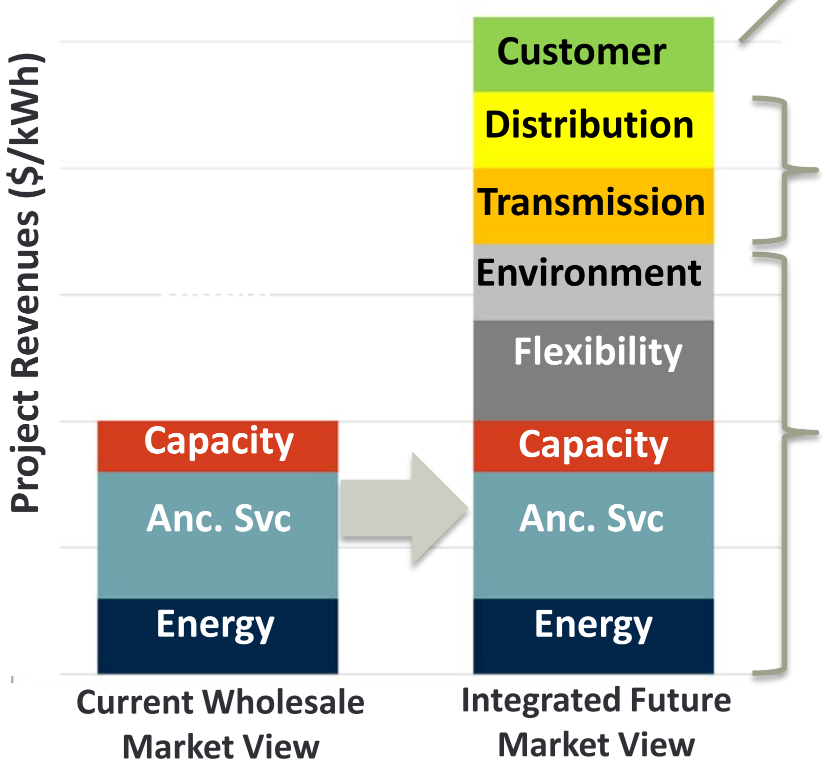
- **Continued storage cost reductions and technology improvements**. Some applications already cost-effective today, but as costs fall further storage will be transformative.
- **Retail customers are focused on cost reduction and control,** including interest in participating in the marketplace through 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 an integral component of our 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

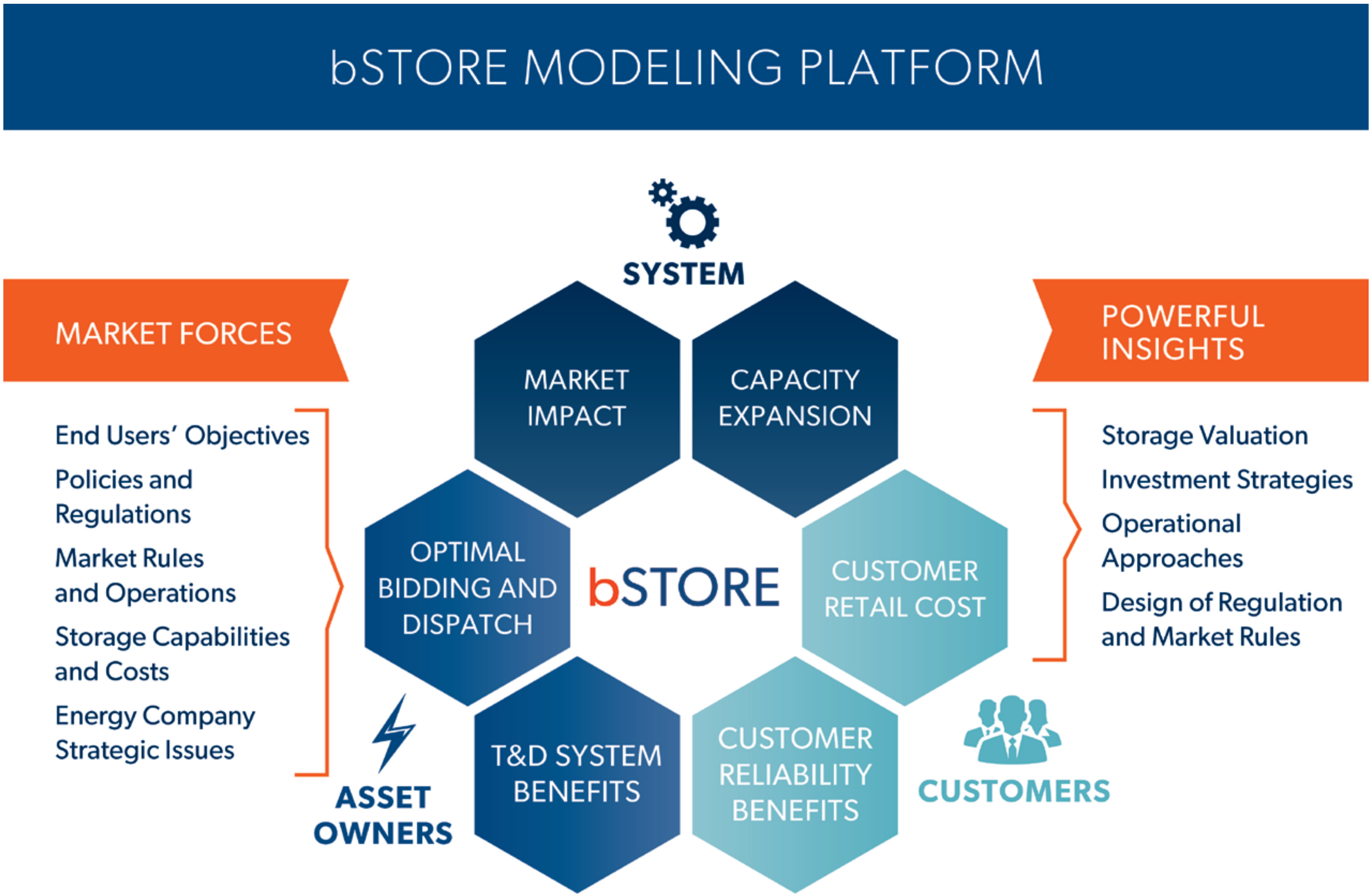
Utility Infrastructure

- 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

Assessing Multiple Value Streams



www.brattle.com/storage

Agenda

- The Storage Value Proposition
- **FERC Order 841**
- Getting to 50 GW Storage Potential
- Significant Roles for States

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 wholesale prices**
- **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 market topics
- 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:

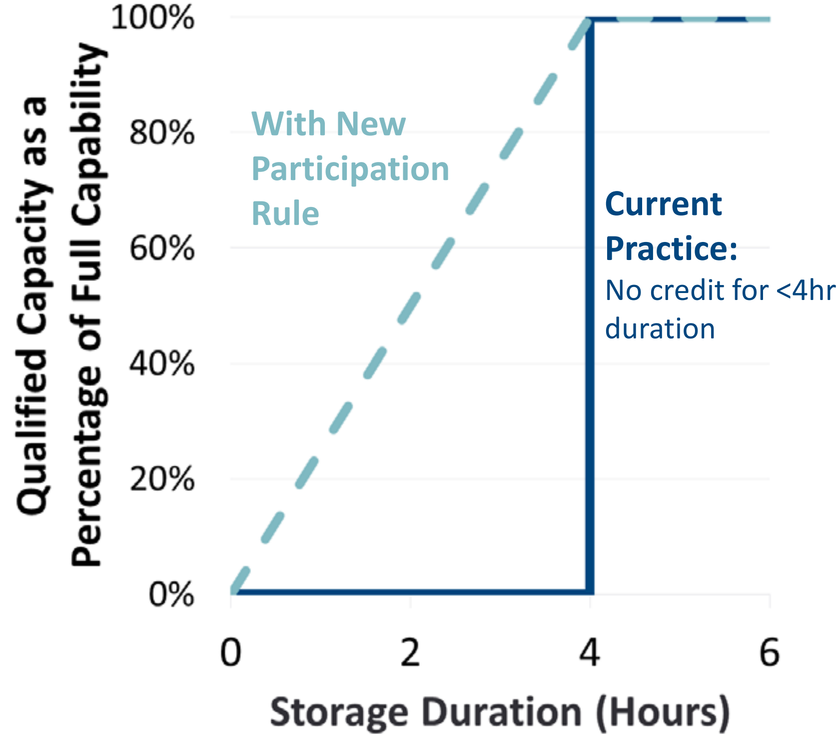
- **Transmission charges** for energy used in charging storage
- **Interactions between federal and state** oversight of distributed energy storage
- **Jurisdiction over behind-the-meter storage** used for both retail and wholesale purposes
- **Responsibilities for ensuring distribution-level reliability** 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.

Capacity Market Value

- **RTOs will have the flexibility to determine their own min discharge duration to qualify as a capacity resource**
  - MISO and NYISO: Currently require 4 hours
  - PJM and ISO-NE: Primarily only allow long duration storage via performance incentives
- **New participation models will likely allow storage to set the capacity to meet minimum discharge duration requirement**
  - De-rates based on the MW storage can discharge continuously over the "minimum run-time"
- **Storage's resource adequacy value will also vary based on market conditions, for example:**
  - Incremental capacity value decreases as more storage is added to the system
  - Observed in Brattle's Texas storage study
  - Unforced capacity ratings would likely incorporate system needs and conditions

Illustrative Example: Storage Capacity Value Before and After 841



Sources:
MISO: Business Practices Manual 11, Section 4.2.4.1
NYISO: ICAP Manual, Section 4.8.2

Market Design Implications

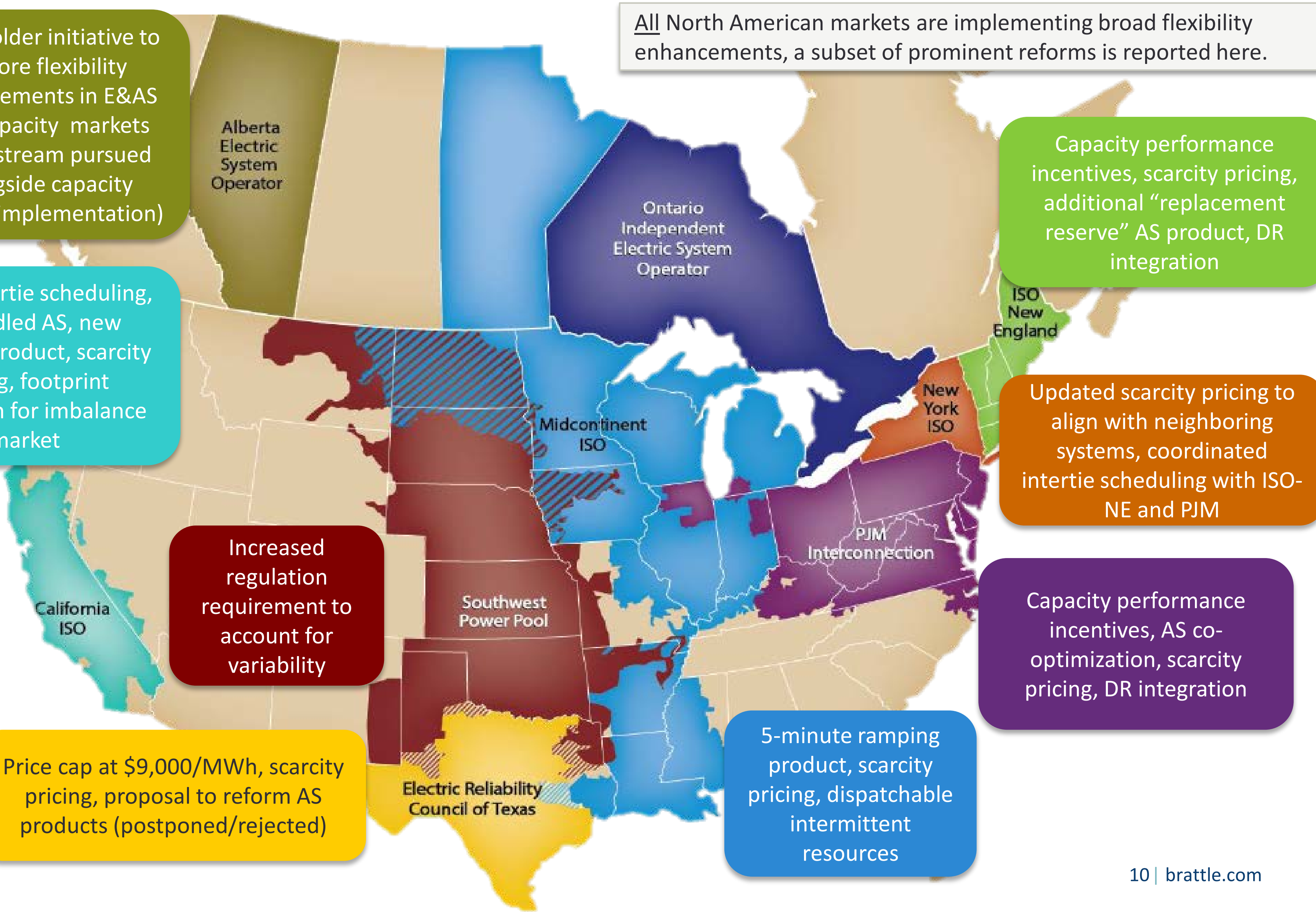
Ancillary to 841: PJM's RegD Market

- **In 2015, PJM made changes to their RegD operations that:**
  - **Decreased the benefits factor** for all RegD resources in all hours and added a cap to RegD resources in some peak hours
  - **Altered the RegD signal**, changing the original energy-neutral logic and sometimes requiring Operators to manually move the RegD signal
- **Storage operators claimed signal changes harmed batteries by altering the "expected" charge and discharge cycle**
  - Some operators needed to derate battery capacity to preserve battery life
  - EDF derated McHenry Storage by 32%; AES claimed a "huge derate of MW capacity" (most companies' derate amounts were confidential)
- **In March 2018, FERC ruled the PJM's updated tariff is not acceptable**
  - PJM's tariff must describe the calculation of the benefits factor curve
  - PJM's tariff must also include signal parameters
  - FERC will lead a technical conference on regulation design

Source: 162 FERC ¶ 61,296 . Order on Complaints and Establishing Technical Conference. March 30, 2018

Market Design Implications
RTO Efforts to Incentivize Flexibility

All North American markets are implementing broad flexibility enhancements, a subset of prominent reforms is reported here.



Stakeholder initiative to explore flexibility enhancements in E&AS and capacity markets (work stream pursued alongside capacity market implementation)

5-min intertie scheduling, unbundled AS, new ramping product, scarcity pricing, footprint expansion for imbalance market

Increased regulation requirement to account for variability

Price cap at $9,000/MWh, scarcity pricing, proposal to reform AS products (postponed/rejected)

Capacity performance incentives, scarcity pricing, additional "replacement reserve" AS product, DR integration

Updated scarcity pricing to align with neighboring systems, coordinated intertie scheduling with ISO-NE and PJM

Capacity performance incentives, AS co-optimization, scarcity pricing, DR integration

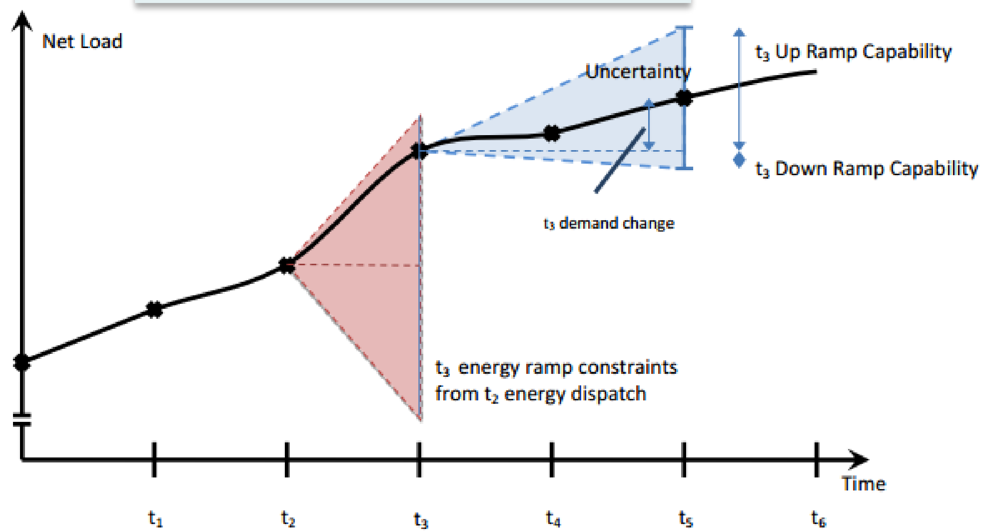
5-minute ramping product, scarcity pricing, dispatchable intermittent resources

Example of Flexibility Enhancements

- **MISO & CAISO added similar flexible ramp products in 2016**
  - Account for growing uncertainty in short-term net load forecasts due to growing wind and solar levels
  - Ensure sufficient ramp capability is held back for potential future net load levels
- **MISO's product**
  - Both day-ahead and real-time
  - Ensures each 5-min interval meets energy requirement
  - Holds back sufficient ramp capability for the subsequent 10 minutes
- **CAISO's product**
  - Designed to meet 5-min ramping need
  - Separate ramp-up and ramp-down products
  - Procured in real time, not day-ahead

MISO Ramp Capability Products

Ramp requirements enforced to ensure that the system can move from t3 to t5 without deploying reserves



Ramp Capability Captures Potential Future Interval Variations in Current Dispatch

Sources:

Nivad Navid and Gary Rosenwald, Ramp Capability Product Design for MISO Markets, July 10,2013

MISO, Business Practices Manual 002, Energy and Operating Reserve Markets

Market Design Principles

Wholesale markets should remain as technology neutral as possible and maximize participation and encourage competition from all resources technically capable of providing needed services

Market prices should send clear signals for all resources to operate in a way that maximizes their value

Market rules should support efficient investment from resources that will create the most value at the lowest cost

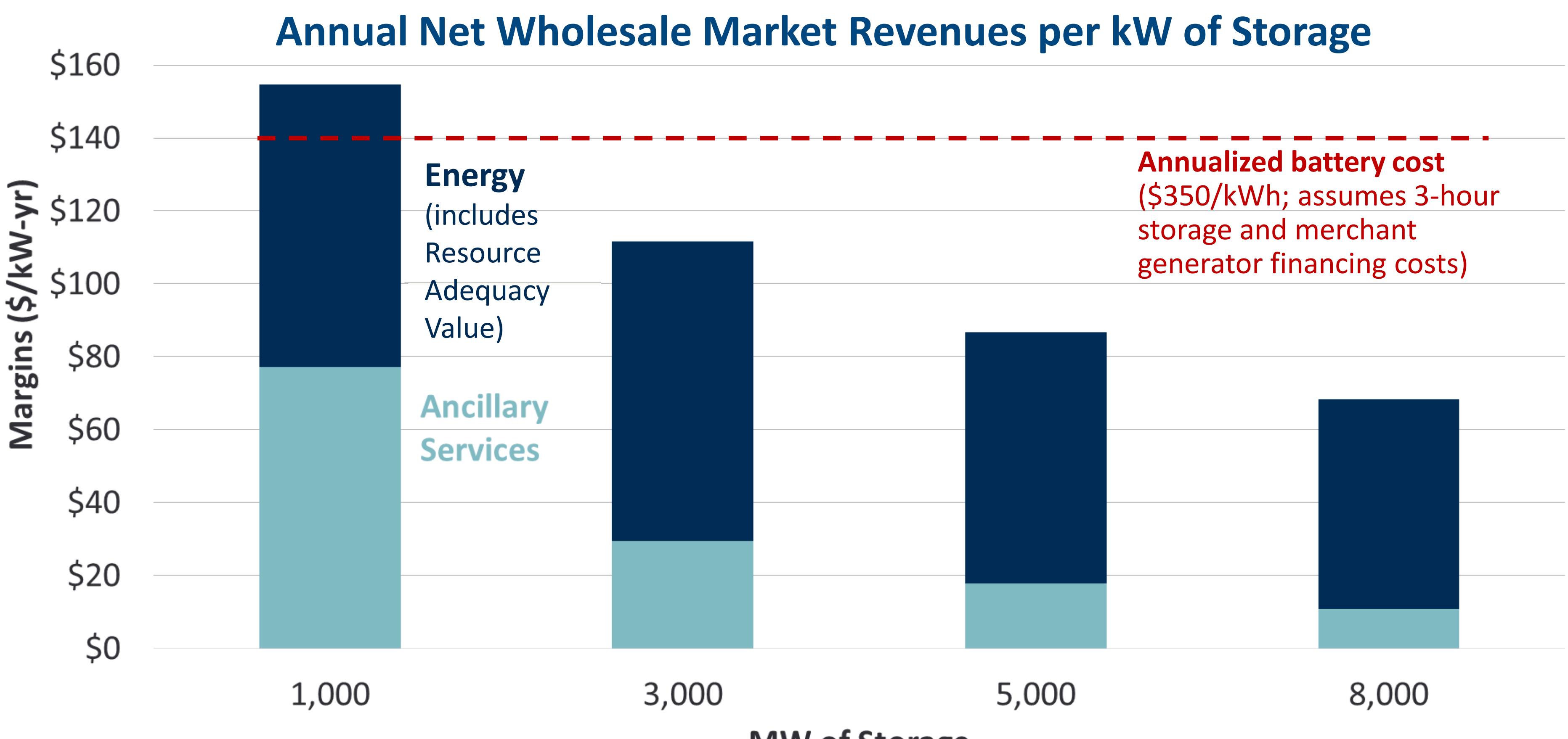
For markets to remain efficient and sustainable, RTO reforms to incorporate storage should continue to follow fundamental design principles.

Agenda

- The Storage Value Proposition
- FERC Order 841
- **Getting to 50 GW Storage Potential**
- Significant Roles for States

Storage Wholesale-Market Value in ERCOT

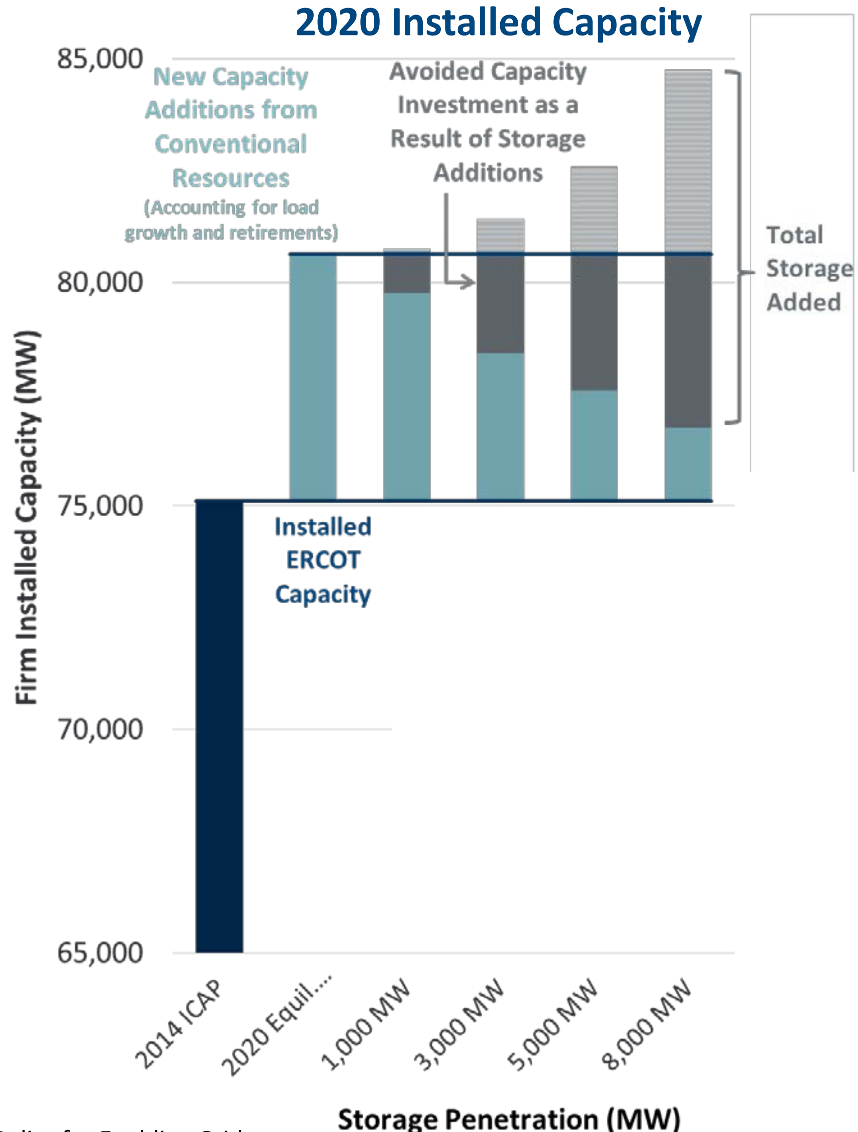
The wholesale market value exceeds costs of $350/kWh for up to 1,000 MW of storage. Adding storage reduces that value as ancillary services get saturated.



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.

Capacity Value of Storage in ERCOT

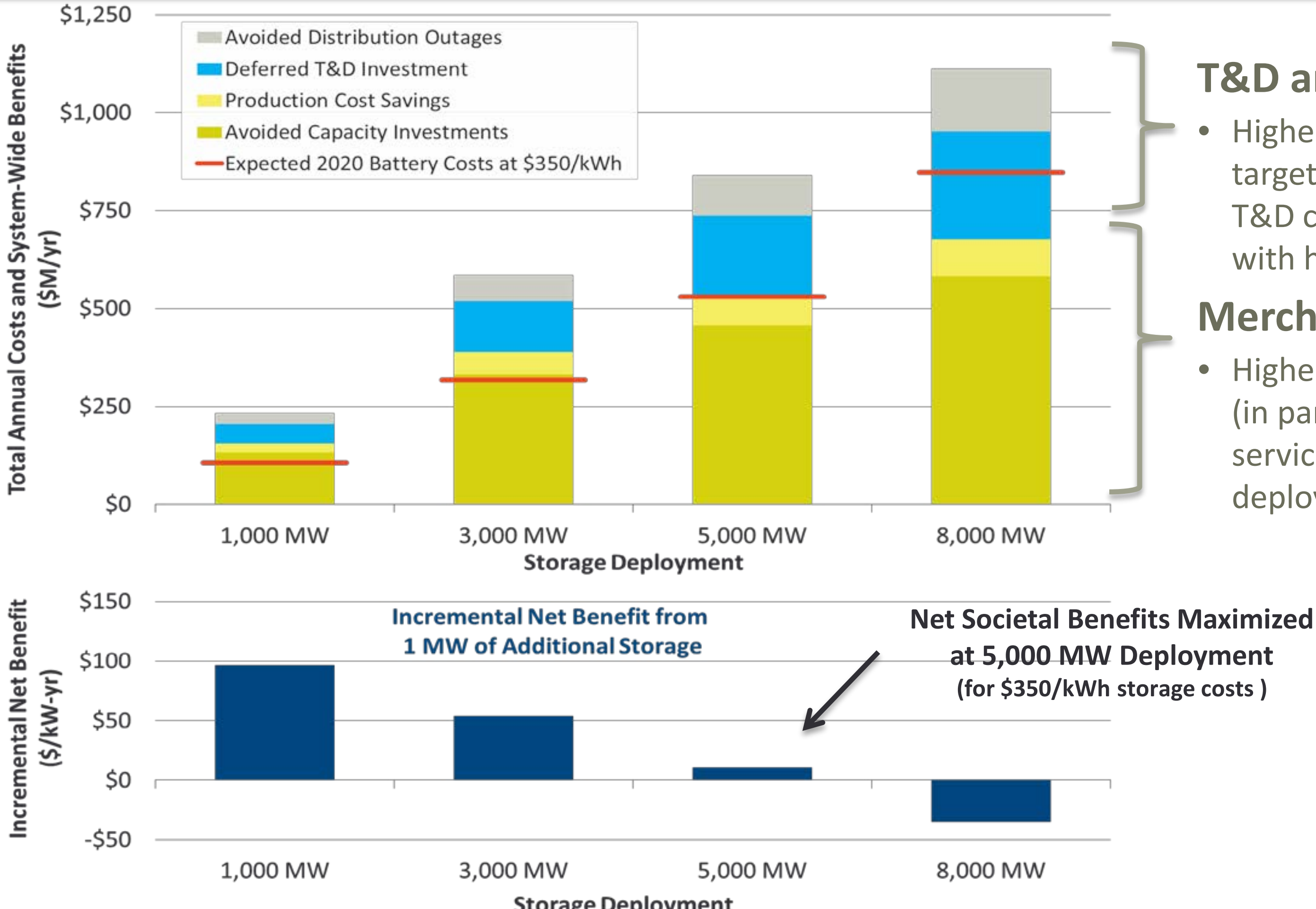
- Detailed simulations of generation investment responses to storage deployment show that the capacity value of (energy-limited) storage declines with market penetration
- ERCOT example: resource adequacy value of 3-hour storage devices:
  - 1,000 MW of storage equivalent to 1,000 MW of conventional generation
  - 5,000 MW of storage has a resource adequacy value equivalent al to 3,100 MW conventional generation
  - 8,000 MW equivalent to 4,500 MW



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.

System-Wide Benefits in ERCOT

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

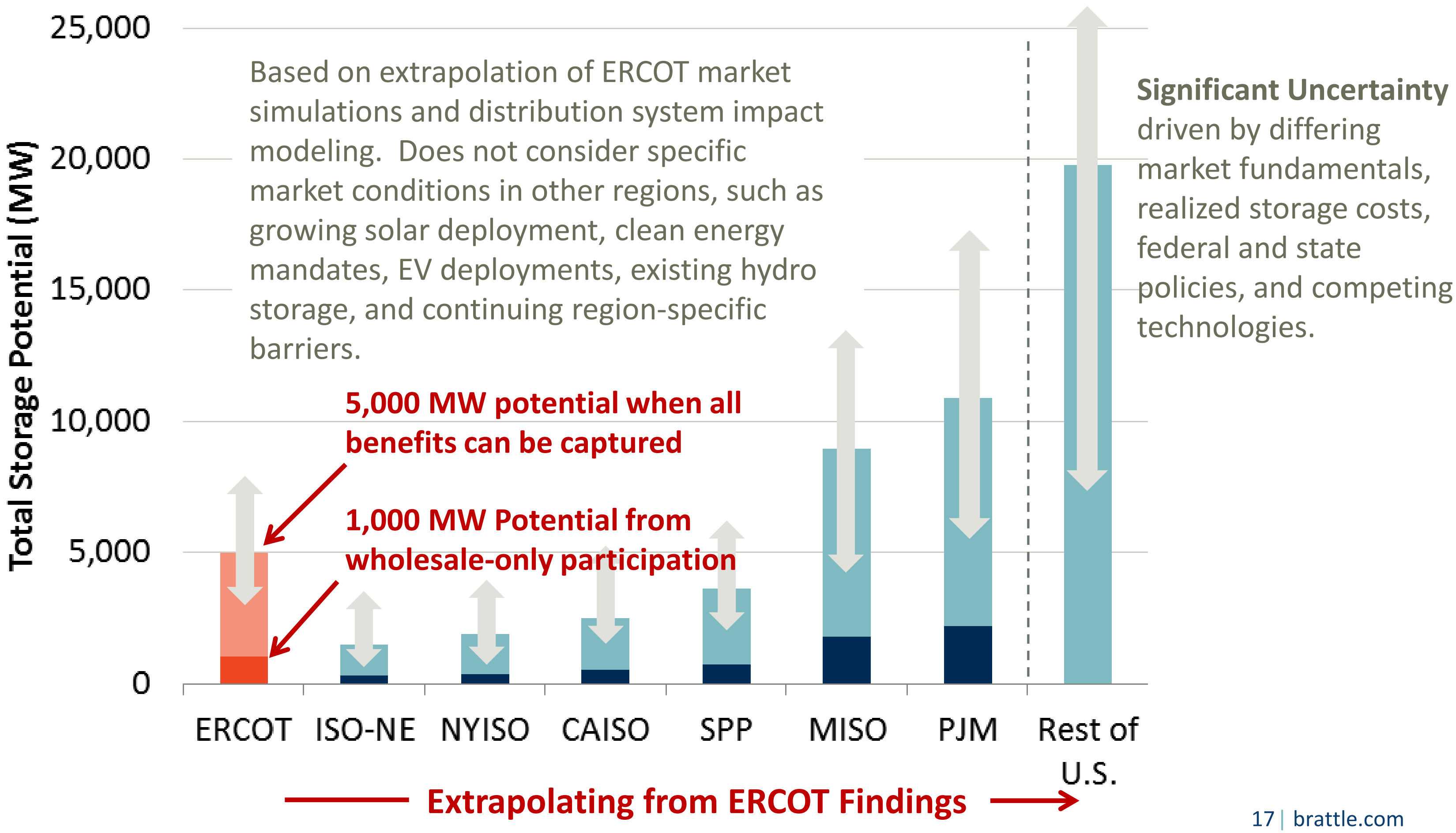
Merchant Value

- 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

Opportunities for storage could increase to 50,000 MW US-wide if <u>all value</u> can be captured. But this will require further action by the states.

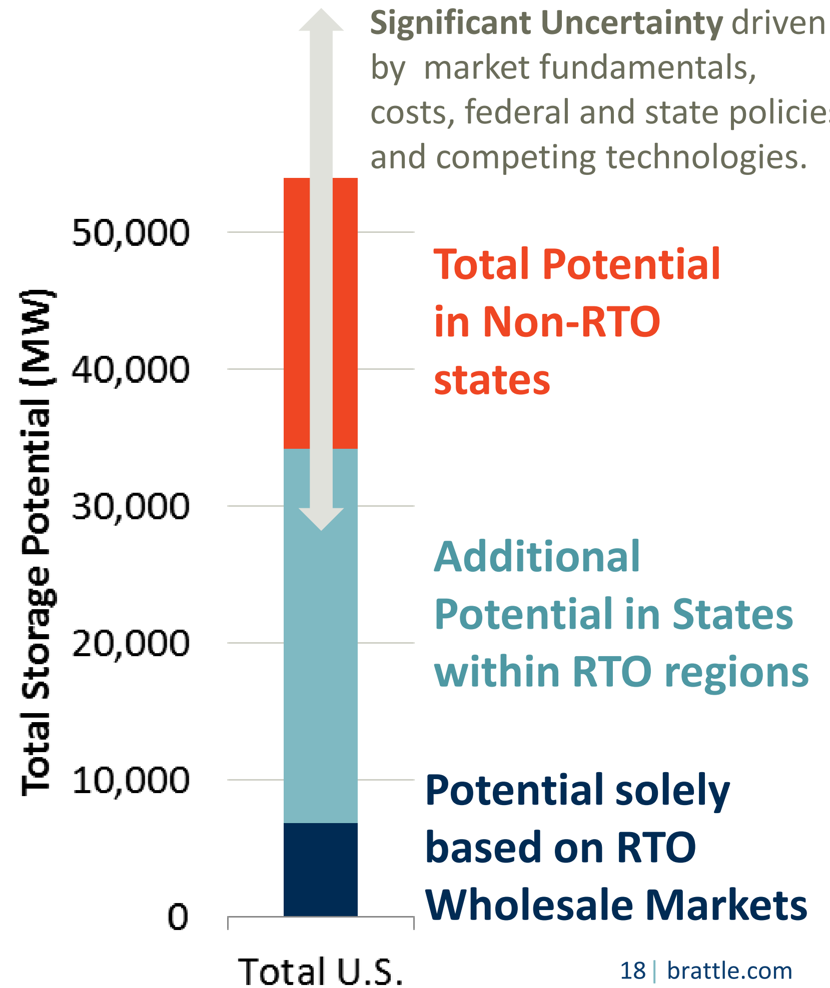


Notes: Extrapolated from ERCOT study based on average 2016 system load

Storage Potential in RTO and Non-RTO Areas

Integrated Resource Planning can affect the implementation of storage in many states, particularly those with high renewable deployment.

- Resource planning is beginning to recognize that storage can help utilities improve their systems' reliability and economics
- IRP evaluations do not <u>yet</u> capture the full value of storage
  - Do not capture full wholesale value
  - Do not generally address T&D and customer reliability value streams
- Much of the opportunities will depend on utility planning and states' views on the value of storage



Agenda

- The Storage Value Proposition
- FERC Order 841
- Getting to 50 GW Storage Potential
- **Significant Roles for States**

State Regulators Play a Significant Role in Unleashing the Value of Storage

Beyond jurisdictional questions, state regulatory action are important to address T&D and customer-related barriers and benefits.

Topics include:

- Limitations on utility ownership and operation of storage
- Storage when considering resource-adequacy and T&D planning processes
- Methodologies for valuing T&D and customer level benefits
- Procurement processes and considerations for benefits of storage
- Services that distribution-connected and behind-the-meter storage can provide
- Dispatch priority for storage simultaneously providing multiple services (e.g., T&D reliability services vs. wholesale market participation)
- Obligations and contracts: avoid double compensation for providing simultaneous services
- Rate design
- Eligibility for Net Energy Metering
- Eligibility to aggregation and participation in utility programs

Source: CPUC Administrative Law Judge's Ruling Seeking Comments On Joint Staff Proposal, Rulemaking 15-03-011, March 26, 2015; Decision on Multiple-Use Application Issues, Rulemaking 15-03-011, November 3, 2017; Stacked Benefits: Comprehensively Valuing Battery Storage in California, The Brattle Group, September 2017; Tackling Barriers to Entry in Energy Storage, CESA, June 28, 2011.

Storage-Specific State Policies

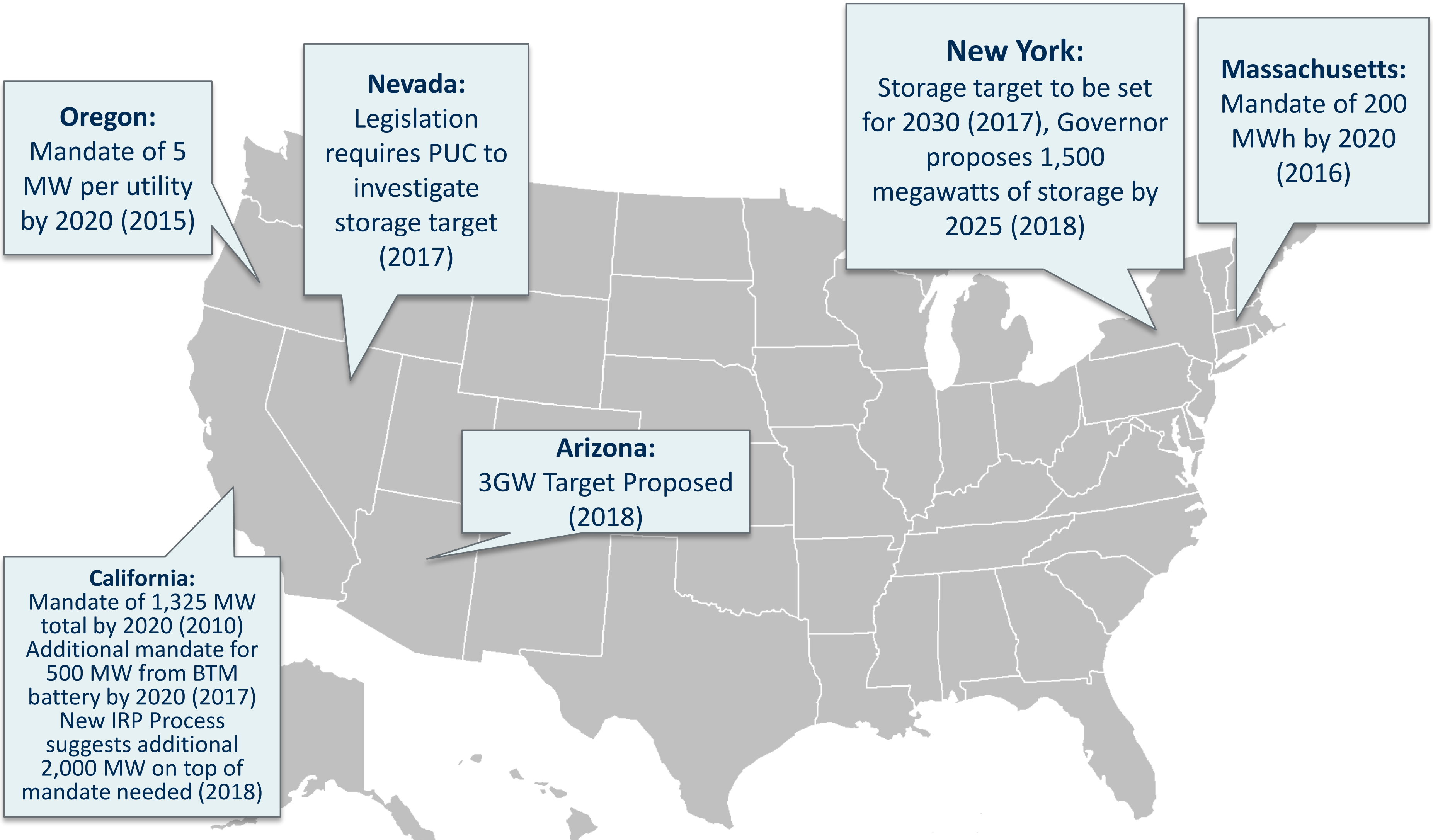
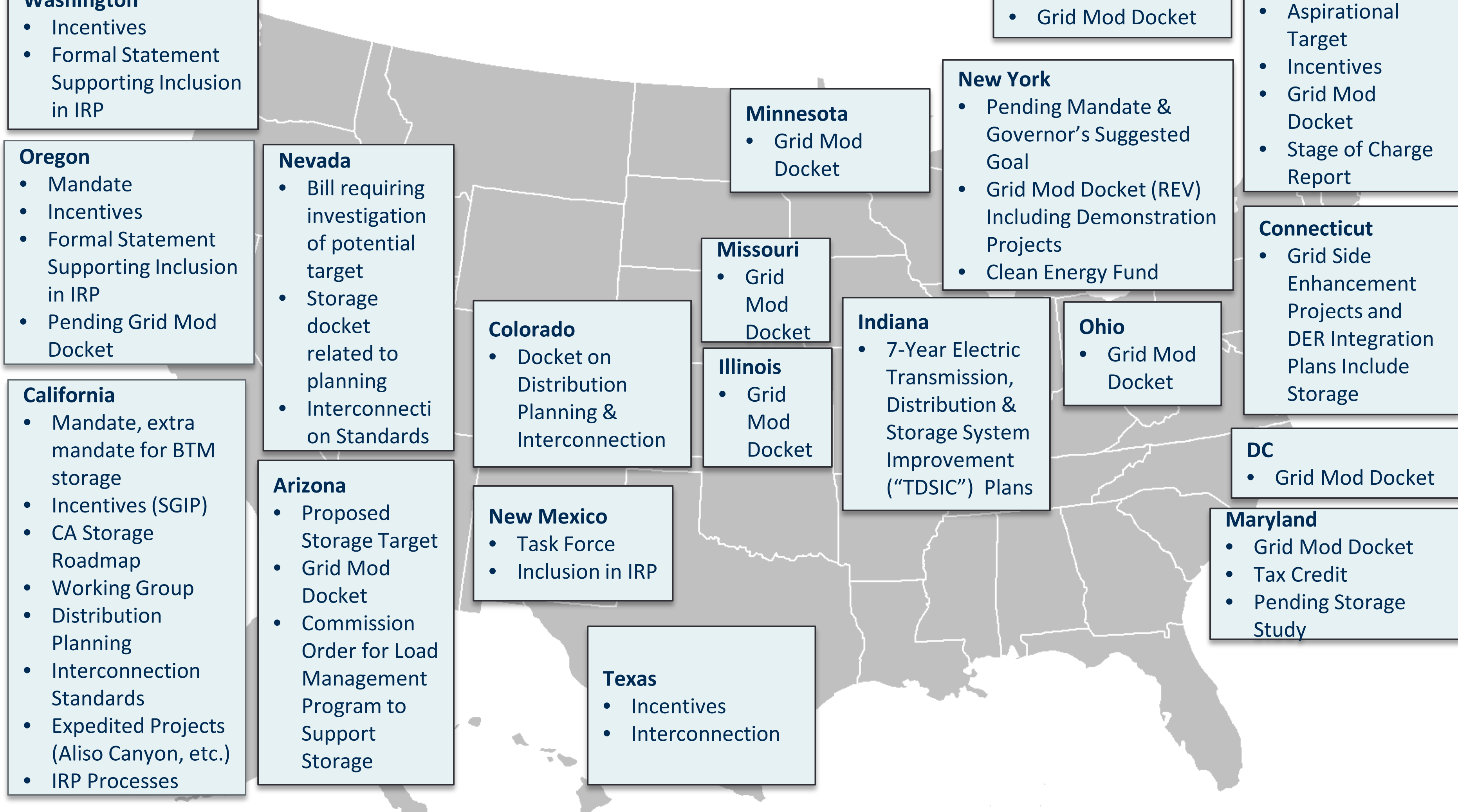


Image Source: Authored by Theshibboleth , 11 July 2006. Available on Wikimedia Commons at:
https://commons.wikimedia.org/wiki/File:Blank_US_Map_(states_only).svg

Active State Regulatory Proceedings that Affect Storage



Washington
- Incentives
- Formal Statement Supporting Inclusion in IRP

Oregon
- Mandate
- Incentives
- Formal Statement Supporting Inclusion in IRP
- Pending Grid Mod Docket

California
- Mandate, extra mandate for BTM storage
- Incentives (SGIP)
- CA Storage Roadmap
- Working Group
- Distribution Planning
- Interconnection Standards
- Expedited Projects (Aliso Canyon, etc.)
- IRP Processes

Nevada
- Bill requiring investigation of potential target
- Storage docket related to planning
- Interconnection Standards

Arizona
- Proposed Storage Target
- Grid Mod Docket
- Commission Order for Load Management Program to Support Storage

Colorado
- Docket on Distribution Planning & Interconnection

New Mexico
- Task Force
- Inclusion in IRP

Texas
- Incentives
- Interconnection

Minnesota
- Grid Mod Docket

Missouri
- Grid Mod Docket

Illinois
- Grid Mod Docket

Indiana
- 7-Year Electric Transmission, Distribution & Storage System Improvement ("TDSIC") Plans

Ohio
- Grid Mod Docket

New York
- Pending Mandate & Governor's Suggested Goal
- Grid Mod Docket (REV) Including Demonstration Projects
- Clean Energy Fund

Vermont
- Grid Mod Docket

New Hampshire
- Grid Mod Docket

Massachusetts
- Aspirational Target
- Incentives
- Grid Mod Docket
- Stage of Charge Report

Connecticut
- Grid Side Enhancement Projects and DER Integration Plans Include Storage

DC
- Grid Mod Docket

Maryland
- Grid Mod Docket
- Tax Credit
- Pending Storage Study

Note: Map illustrates notable policies and is not exhaustive. Grid Mod Docket refers to Grid Modernization Dockets- broad dockets that address changing technologies (usually including storage) and their impacts of utility planning, business models, or regulation. Image source same as previous slide.

Other Questions that will Affect Market Potential

- **How is storage competing with other resources?**
  - Gas-fired combined cycles, combustion turbines, or diesel engines?
  - Demand response?
- **How can storage provide environmental value?**
  - Store excess (curtailed) renewable and clean energy?
  - Reduce inefficiencies of cycling traditional generators?
  - Reduce local air pollution in urban areas?
- **How is storage considered in retail rate design?**
  - How might storage shift costs between customers?
  - How do utilities and state regulatory commissions address incentives questions around customers' storage investments?
  - How do we avoid stranding investments in the future as costs decrease and/or retail rates change?
- **What is the role of the utility?**
  - Can they participate in the storage initiatives?
  - Can they help the industry increase scale and move down the learning curve?
  - How can competitive forces be harnessed to provide utilities the right incentives?

Takeaways

Doubling the value of accessible storage benefits (or cutting storage costs in half) increases the storage market potential by a factor of 5!

As costs decline, the market potential for storage grows significantly

- At an installed cost of $350/kWh, the estimated storage market would grow to:
  - ERCOT Study: 1,000 MW (3,000 MWh) in ERCOT solely based on wholesale market benefits, increases to 5,000 MW (15,000 MWh) if all value streams can be captured
  - 7,000 MW in U.S. RTO markets solely based on wholesale market benefits
  - 35,000 MW in U.S. RTO markets and 50,000 MW nation-wide if all value streams (wholesale markets, T&D, customer and outage reduction benefits) can be captured
- Despite the significant potential benefits, storage still faces economic, regulatory, and market barriers that limit its overall market potential
  - Costs are still relatively high today
  - FERC Order 841 is a helpful step in reducing barriers in wholesale markets
  - State policies and regulations will be necessary to unlock T&D and customer values
- Many important policy, market, and business-model questions will need to be addressed

About The Brattle Group

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governmental agencies worldwide.

We combine in-depth industry experience and rigorous analyses to help clients answer complex economic and financial questions in litigation and regulation, develop strategies for changing markets, and make critical business decisions.

Our services to the electric power industry include:

- Climate Change Policy and Planning
- Cost of Capital
- Demand Forecasting Methodology
- Demand Response and Energy Efficiency
- Electricity Market Modeling
- Energy Asset Valuation
- Energy Contract Litigation
- Environmental Compliance
- Fuel and Power Procurement
- Incentive Regulation
- Rate Design and Cost Allocation
- Regulatory Strategy and Litigation Support
- Renewables
- Resource Planning
- Retail Access and Restructuring
- Risk Management
- Market-Based Rates
- Market Design and Competitive Analysis
- Mergers and Acquisitions
- Transmission

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

www.brattle.com/storage

Additional Reading

"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," Ioanna Karkatsouli, James Mashal, Lauren Regan, Judy Chang, Matthew Davis, Johannes P. Pfeifenberger, and Kathleen Spees, Prepared for Oncor, March 2015

Offices


BOSTON


NEW YORK


SAN FRANCISCO


WASHINGTON, DC


TORONTO


LONDON


MADRID


ROME


SYDNEY