The Value of Distributed Electrical Energy Storage in Texas
Proposed Policy for Enabling Grid-Integrated Storage Investments

PRESENTED TO
Energy Storage Policy Forum 2015
Washington, DC

PREPARED BY
Judy Chang
Kathleen Spees
Johannes Pfeifenberger
Matthew Davis

January 29, 2015
Disclaimer

The analysis and projections that we provide in this document are necessarily based on assumptions with respect to conditions which may exist or events which may occur in the future. No one can give you any assurance that the assumptions used will prove to be correct or that the forecasts will match actual results of operations. Our analysis, and the assumptions used, are also dependent upon future events that are not within our control or the control of any other person, and do not account for certain regulatory uncertainties. Actual future results may differ, perhaps materially, from those presented here.

All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group, Inc. or its clients.
Agenda

Summary

Three Perspectives of Storage Benefits

Aggregate Value of Storage
  - Merchant Value
  - Societal or System-Wide Benefits
  - Consumer Benefits

Proposed Regulatory Framework

Impact on Wholesale Market and Generators
Summary

Deploying grid-integrated electricity storage on distribution systems across Texas could provide substantial net benefits to the state

- Up to 5,000 MW of distributed energy storage cost effective in ERCOT from a system-wide perspective at storage cost $350/kWh
- Total customer benefits (lower bills and improved reliability) would exceed costs
- Assumes storage deployment reduces but does not eliminate need for new generation

Current market and regulatory mechanisms will not enable cost-effective deployment of this innovative technology

- Wholesale market participants cannot capture T&D value (avoided outages, deferred T&D costs)
- Wires companies cannot justify large-scale storage deployment solely based on T&D savings (i.e. without also capturing and passing on to customers the wholesale market value)

Capturing the full value of storage to enable cost-effective investments requires new policy frameworks. For example:

- Allow TDSPs to deploy storage that is optimized to capture T&D and reliability benefits
- Auction off the rights to dispatch that storage into the wholesale market to third parties
- Use the auction revenues to offset storage costs to retail customers
- Ensure expected reliability and T&D benefits of deployment plan exceed net customer costs
Estimating Economic Benefits of Storage from Three Perspectives

**Merchant Benefits**
- Profits that a private investor could capture in the ERCOT wholesale market
- Driven by energy arbitrage value and ancillary service prices
- **Importance:** determines (a) whether wholesale market incentives by themselves are sufficient to attract investment in storage; and (b) the offset to storage costs if deployed by wires company for T&D/reliability benefits

**“Societal” or “System-Wide” Benefits**
- Economy-wide benefits, including reduction in production, investment, and outage costs (regardless of whether suppliers or customers benefit)
- Also known as “total resource cost” benefits
- **Importance:** PUCT transmission policy order requires analysis of net “societal” or “system” benefits

**Customer Benefits**
- Customer bill savings from reduced wholesale prices, deferred transmission and distribution costs, and rebated merchant value
- Increase in realized distribution system reliability (reduced outages)
- **Importance:** customer advocates’ and distribution utilities’ primary interest, also a key metric from a public policy perspective
Merchant Value of Storage in Wholesale Market

- Even at the low projected battery costs, the wholesale market value of storage (without capturing T&D and reliability benefits) is too limited to support merchant investments at a meaningful scale.
- Particularly true if investment risks were to exceed the 8% ATWACC assumed for merchant generators.

**Merchant Value**

*Notes:* Merchant value represents the margins that a merchant investor would receive by participating in ERCOT’s energy and ancillary services markets; assuming storage with a 3-hour discharge capability, 85% round-trip efficiency, and no other variable operations and maintenance (VOM) costs. Storage costs of $350/kW-y are based on battery vendors’ estimates of $200/kWh as quoted to Oncor, plus an Oncor-estimated installation cost of $150/kWh, plus fixed operations and maintenance costs equal to 1% and 2% of investment costs for the “expected” and “high” cost levels.
Societal / System-Wide Benefits

- Incremental value of storage exceeds its cost up to approx. 5,000 MW.
- Beyond that point, incremental investment is not beneficial unless the cost of storage drops below $350/kWh.

Notes: The expected 2020 battery costs are annualized based on Oncor’s 6.3% ATWACC, with 15- and 30-year assumed lifetime for the battery and balance of plant respectively.
Consumer Benefits

- Customers experience overall benefits through lower bills and improved reliability.
- With the proposed policy framework, customer costs are offset by the merchant value a third-party market operator obtains in the ERCOT wholesale markets.

### Total Consumer Benefits

<table>
<thead>
<tr>
<th></th>
<th>$1,250</th>
<th>$1,000</th>
<th>$750</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Distribution Outages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deferred T&amp;D Investment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Purchase Cost Savings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bill Offset from Merchant Value (75% Returned)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected 2020 Battery Costs at $350/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** The expected 2020 battery costs are annualized based on Oncor’s 6.3% ATWACC, with 15- and 30-year assumed lifetime for the battery and balance of plant respectively.
Consumer Benefits – Bill Impact

Impact on Typical Residential Bill in 2020 for 3,000 MW of Storage ERCOT-wide

Notes: We assume that Oncor installs 1,000 MW out of 3,000 MW of storage deployed on an ERCOT-wide basis, with storage costs and wholesale-market proceeds reflecting the same proportion of installations. Oncor customers realize deferred transmission and distribution investment benefits based on the 1,000 MW installed on Oncor’s system. The avoided distribution outage value shown is for a typical residential customer on a feeder with storage. Customers not located on a feeder with storage would not realize these reliability benefits.
Proposed Regulatory Framework

- Targeted distribution-level deployment and operations needed to allow the utility to realize reliability, T&D, and wholesale market benefits
- Utility-based deployment can simultaneously capture these benefits without regulated utilities transacting in competitive wholesale markets
  - Wires companies would auction off wholesale market participation to unregulated entities who would then bid the storage assets into the markets
  - Auction proceeds used to offset regulated storage costs, thereby reducing customer costs
  - Commission would evaluate and approve storage deployment plan only if beneficial from a net customer cost perspective (e.g., based on experience from limited initial deployment)
- Framework allows wires companies to make investments in electricity storage and recover investment costs through regulated rates as long as:
  - A significant fraction of the value of these storage assets is associated with reliability and T&D benefits that are not captured through wholesale market participation
  - The incremental reliability and T&D benefits are expected to exceed net customer costs by a sufficient margin
- Approach solves the barriers created by fragmented value streams that will otherwise lead to under-investment in electric energy storage
Impact on Wholesale Market and Generators
Simulating Generation Investment Response

- Simulated ERCOT’s energy-only market in 2020:
  - With full ORDC curve
  - With 2011 and 2012 weather years to arrive at realistic distribution of CC margins

- Evaluated the likely investment response by conventional generation if storage is added to the ERCOT system

- Yields reserve margin consistent with a market outcome at the CONE of combined cycle (CC) unit (estimated at $149/kW-yr in 2020)
  - 5,000 MW of storage results in 3,100 MW of reduced generation investment (or increased retirements)

Impact on Wholesale Market and Generators
Charging/Discharging Impact on Price

Average Charge/Discharge and Average Price by Hour Ending

Notes:
Price with storage reflects 3,068 MW of less generation investment compared to the price without storage
Results represent the weighted average of the 2011 and 2012 weather year results
Impact on Wholesale Market and Generators

Price Duration Curve with/without Storage

- Fewer high-priced scarcity hours
- Higher-priced non-scarcity peak hours
- Higher-priced off-peak hours

Notes:
- Price with storage reflects 3,068 MW of less generation investment compared to the price without storage.
- Results represent the weighted average of the 2011 and 2012 weather year results.
Impact on Wholesale Market and Generators
CC Energy Margins with/without Storage

Because of investment response CCs earn margins equal the cost of new entry with and without batteries.

Adding storage increases the percentage of time a CC runs profitably.

Profitable annual operating hours increase by 7 percentage points.

Notes:
Margins calculated based on the representative CC unit (Jack County) used for determining the equilibrium reserve margin. Results represent the weighted average of the 2011 and 2012 weather year results.
The views expressed in this presentation are strictly those of the presenter(s) and do not necessarily state or reflect the views of The Brattle Group, Inc. or its clients.
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, rigorous analyses, and principled techniques 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 & Regulatory Finance
- Demand Forecasting & Weather Normalization
- Demand Response & Energy Efficiency
- Electricity Market Modeling
- Energy Asset Valuation & Risk Management
- Energy Contract Litigation
- Environmental Compliance
- Fuel & Power Procurement
- Incentive Regulation
- Market Design & Competitive Analysis
- Mergers & Acquisitions
- Rate Design, Cost Allocation, & Rate Structure
- Regulatory Compliance & Enforcement
- Regulatory Strategy & Litigation Support
- Renewables
- Resource Planning
- Retail Access & Restructuring
- Strategic Planning
- Transmission
Offices

NORTH AMERICA

Cambridge  New York  San Francisco  Washington, DC

EUROPE

London  Madrid  Rome