U.S. Energy Storage – State of the Market

Prepared for:

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1. Deployment Trends
U.S. Q4 2017 Deployments in Megawatts Down 56% From Previous Year

U.S. Quarterly Energy Storage Deployments by Segment (MW)

Deployments (MW)

Residential
Non-Residential
Front-of-the-Meter


Source: GTM Research
U.S. Q4 2017 Deployments in Megawatt-Hours Down 57% From Previous Year

U.S. Quarterly Energy Storage Deployments by Segment (MWh)

Source: GTM Research
Top Energy Storage Markets, 2017: California Rules BTM Market, Texas leads FTM

**Top 3 Markets by Segment in 2017 (Power Capacity)**

<table>
<thead>
<tr>
<th></th>
<th>Residential Deployments (kW)</th>
<th>Non-Residential Deployments (MW)</th>
<th>Front-of-the-Meter Deployments (MW)</th>
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<tbody>
<tr>
<td>1</td>
<td>California</td>
<td>California</td>
<td>Texas</td>
</tr>
<tr>
<td>6,544</td>
<td>45.1</td>
<td>51.8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>All Others*</td>
<td>All Others*</td>
<td>California</td>
</tr>
<tr>
<td>5,859</td>
<td>2.4</td>
<td>43.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hawaii</td>
<td>New York</td>
<td>Arizona</td>
</tr>
<tr>
<td>4,332</td>
<td>1.8</td>
<td>25.0</td>
<td></td>
</tr>
</tbody>
</table>

*GTM Research is currently monitoring eight individual markets: Arizona, California, Hawaii, Massachusetts, New Jersey, New York, PJM and Texas.

Source: GTM Research
Lithium-Ion Technology Continues the Trend of More Than 94% Share

Quarterly Energy Storage Deployment Share by Technology (MW %)

Energy Storage Deployments by Technology (MW)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%


- Lithium Ion
- Lead Acid
- Sodium Chemistries
- Flow - Vanadium
- Flow - Zinc
- Other

"Other" includes flywheel and unidentified energy storage technologies.

Source: GTM Research
Corporate Investments in Energy Storage Reached $1.4B in 2017

Disclosed Corporate Investments in Energy Storage, 2010-Q4 2017 (Million $, Number of Deals)

Source: GTM Research

Note: The total disclosed investment in 2014 was boosted by a rumored $250 million investment in Boston-Power (shaded in the figure above); Data excludes battery materials and upstream companies. 2014 data differs from U.S. Energy Storage Monitor 2014 Year in Review due to exclusion of EV startup Atieva and inclusion of stealth startup Fluidic Energy.
Historical System Price Trends: Front-of-the-Meter Prices Down 3% to 9% Year-Over-Year

**Historical System Price Trends: Utility-Scale (2-Hour, $/kW)**

- Q1 2015: $2,800, $2,400, $2,000, $1,600, $1,200, $800, $400
- Q1 2016: $2,600, $2,400
- Q1 2017: $2,400
- Q1 2018: $1,700

Median Value

**Historical System Price Trends: Utility-Scale (30-Minute, $/kW)**

- Q1 2016: $1,300, $1,100, $900, $700, $500
- Q1 2017: $1,200, $1,050
- Q1 2018: $925

Source: GTM Research

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Historical System Price Trends: Behind-the-Meter Non-Residential Continues Downward Slide

**Historical System Price Trends: Non-Residential ($/kW)**

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Median Value</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Q1</td>
<td>$3,000</td>
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<td>$2,900</td>
<td>$2,750</td>
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<td>$2,100</td>
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<td>$2,000</td>
<td>$1,900</td>
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<td>$1,800</td>
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<td>$1,800</td>
</tr>
</tbody>
</table>

Source: GTM Research

**Historical System Price Trends: Residential ($/kW)**

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Median Value</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Q1</td>
<td>$4,000</td>
<td>$4,000</td>
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<tr>
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<td>$2,600</td>
<td>$2,600</td>
<td>$2,200</td>
<td>$2,000</td>
<td>$2,000</td>
</tr>
<tr>
<td></td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
</tr>
</tbody>
</table>

Source: GTM Research
2. Market Drivers
Behind-the-Meter Policy and Market Developments, Q1 2018

**Colorado**

- Members of the Colorado State Senate Agriculture, Natural Resources and Energy Committee voted to send Senate Bill 18-009, which would ensure customers have the right to install and use electricity storage, to the state Senate; such bills are key for reducing customer barriers to installing storage.

**California**

- CPUC issued an order on storage for virtual net metering customers; it also established a working group to develop a greenhouse gas signal for SGIP-funded energy storage projects. The CPUC also issued guidance for multiple use applications.

**Arizona**

- A massive energy modernization effort was proposed by the Arizona Corporate Commission, including a 3 GW energy storage target.

**New Mexico**

- A BTM storage tax credit bill was introduced in the New Mexico state legislature.

**New York**

- Con Edison initiated the next stage of its Demand Management Program, which includes incentives for battery and thermal storage. Governor Cuomo proposed a bold 1.5 GW energy storage target alongside announcements of $260 million in funding from the state’s green bank and NYSERDA. Orange & Rockland announced an NY REV demonstration project to explore storage value streams via a 4 MW/8 MWh storage portfolio.

**Massachusetts**

- MA DOER announced the results of the SMART auction. MA DPU approved new rates for Eversource DER customers that include a residential demand charge. ACES award winners were announced.

**Maryland**

- Maryland’s storage tax credit officially launched in January 2018.

**Virginia**

- A BTM storage tax credit bill was introduced in the Virginia state legislature.

**Florida**

- The state legislature introduced bills that, if passed, would establish a pilot program to explore resilience benefits from DERs including storage.

**Hawaii**

- A bill to establish a storage tax credit was introduced in the Hawaii State Senate.
California

Natural-gas peaking assets were dealt a serious blow, as both existing (PG&E) and planned (SCE) units are being re-examined with an eye toward replacing them with energy storage. The CPUC released a decision on multiple use cases. PG&E’s latest energy storage procurement awarded 165 MW of energy storage projects, primarily at the transmission level.

Arizona

A massive energy modernization effort was proposed by the Arizona Corporate Commission, including a 3 GW energy storage target, while Salt River Project released a new RFP.

Texas

The Public Utility Commission of Texas moved to deny AEP’s proposed energy storage deferral project, but opened a docket to study the issue that will consider storage ownership by distribution utilities in Texas.

Colorado

Xcel announced median bid prices for storage and renewable-paired storage for projects targeting 2023 completion dates, indicating the industry’s optimism on continuing price declines.

Minnesota

Great River Energy launched a 10 MW solar-paired storage RFP.

Michigan

Michigan’s PSC moved to require examination of energy storage in new integrated resource planning guidelines.

New Hampshire

HB 1647, which permits distribution utilities to own storage and monetize it in wholesale markets, was introduced in the New Hampshire General Court, the state legislature.

New York

Governor Cuomo proposed a bold 1.5 GW energy storage target alongside announcements of $260 million in funding from the state’s green bank and NYSERDA. NYISO refined storage participation and eligibility. Orange & Rockland announced an NY REV demonstration project to explore storage value streams via a 4 MW/8 MWh storage portfolio.

Massachusetts

Winners for the Advancing Commonwealth Energy Storage (ACES) program were announced – 26 projects across a variety of use cases.

North Carolina

Duke released its updated 2017 integrated resource plan, including the potential for 75 MW of energy storage.

Federal

FERC ruled in favor of energy storage participation and eligibility in wholesale markets. A new energy storage tax credit was introduced in the U.S. House of Representatives, though its future is unclear. The budget resolution from February 2018 notably excluded energy storage while extending tax credits to many other technologies.

ISO / RTO Markets

Activity continues in proceedings in PJM and MISO—the latest MISO working group meeting discussed a potential new resource type for storage.

Great River Energy

FPCB released a decision on multiple use cases. PG&E’s latest energy storage procurement awarded 165 MW of energy storage projects, primarily at the transmission level.

Salt River Project

A massive energy modernization effort was proposed by the Arizona Corporate Commission, including a 3 GW energy storage target, while Salt River Project released a new RFP.
On February 15th FERC released draft final rules adopting participation and eligibility requirements for energy storage in ISOs and RTOs. The participation model for electric storage resources must:

- Ensure that a resource using the participation model for electric storage resources in an RTO and ISO market is eligible to provide all capacity, energy, and ancillary services that it is technically capable of providing.
- Ensure that a resource using the participation model for electric storage resources can be dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer consistent with rules that govern the conditions under which a resource can set the wholesale price.
- Account for the physical and operational characteristics of electric storage resources through bidding parameters or other means.
- Establish a minimum size requirement for participation in the RTO and ISO markets that does not exceed 100 kW. Also requires that the sale of electric energy from the RTO or ISO market to an electric storage resource that the resource then resells back to those markets must be at the wholesale locational marginal price.
Storage Modeled, Eligible or Mandated in Utility IRPs (MW)

Estimated Total Opportunity:
5.1 GW, 16.8 GWh

Source: GTM Research
Massachusetts has several large solar-plus-storage projects in the pipeline which will be affected, but incentive programs such as the ACES project grants will insulate the solar-plus-storage market during the short-term tariff years.

North Carolina’s emerging solar-plus-storage market will be dramatically affected in the short term as economics were just beginning to break even.

Florida resiliency concerns will cause solar-plus-storage adoption despite tariffs, but economics will be affected. Legislative muscle will be required to incentivize resiliency.

Texas’ solar market was on the cusp of taking off, particularly in West Texas, but solar tariffs will slow adoption, limiting storage’s role.

Arizona’s solar economics, as demonstrated by the 4.5 cent solar-plus-storage PPA signed by utility TEP in 2017, will allow solar-plus-storage to flourish despite tariffs.

California’s new-build utility installations will be affected, but the side effects of its existing solar capacity (such as the notorious “duck curve”) will exist regardless of new build, giving storage an opportunity to pair with existing resources.

In Minnesota, the economics for solar-plus-storage will stall what was an emerging market with several innovative projects in the pipeline.

Its island setting and rich solar resources ensure that Hawaii is still an attractive market, and we expect its solar-plus-storage capacity to grow despite the tariffs.

Large S+S pipeline (>10 MW)
Medium S+S pipeline
Some historical S+S
Natural Gas Peakers At Risk
Base Case Levelized Cost of Energy – Peaking Gas Combustion Turbine vs. 4hr Li-ion Battery Storage ($/MWh)

- Within Five Years, Storage Begins To Compete Head-to-Head
- Within Ten Years, Storage Almost Always Wins

4-Hour Storage Should be Sufficient to Meet Peaker Needs ~40% of Starts

Source: GTM Research, Wood Mackenzie

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3. Outlook
Massachusetts Makes a Big Splash, Other Pipelines Remain Steady

U.S. Front-of-the-Meter Energy Storage Pipeline by Market, Q3 2015-Q4 2017 (MW)

Source: GTM Research
U.S. Energy Storage Annual Deployments Will Reach 3.3 GW by 2023

## U.S. Annual Energy Storage Deployment Forecast, 2012-2023E (MW)

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential</th>
<th>Non-Residential</th>
<th>Front-of-the-Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>231</td>
<td>215</td>
<td>3,327</td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2014</td>
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<td>2015</td>
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</tr>
<tr>
<td>2023E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: GTM Research
Energy Storage Will Constitute a $3.8 Billion Market by 2023

U.S. Annual Energy Storage Market Size, 2012-2023E (Million $)

Source: GTM Research
Thank you!

Daniel Finn-Foley
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finn-foley@gtmresearch.com

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