Energy Storage - Evolution and Revolution on the Electric Grid

Prepared For:

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Power Market Fundamentals

- Long-term Supply & Demand Outlooks
- 20-year Wholesale & Retail Price Outlooks

Regional Market Dynamics

- Policy and Regulation Analysis
- Thermal & Renewable Databases and Demand Outlooks

Technology Value Chain Evolutions

- Wind, Solar, Storage, and Grid Edge Competitive Landscapes
- Technology Cost and Performance Outlooks

We guide companies leading the electricity transformation

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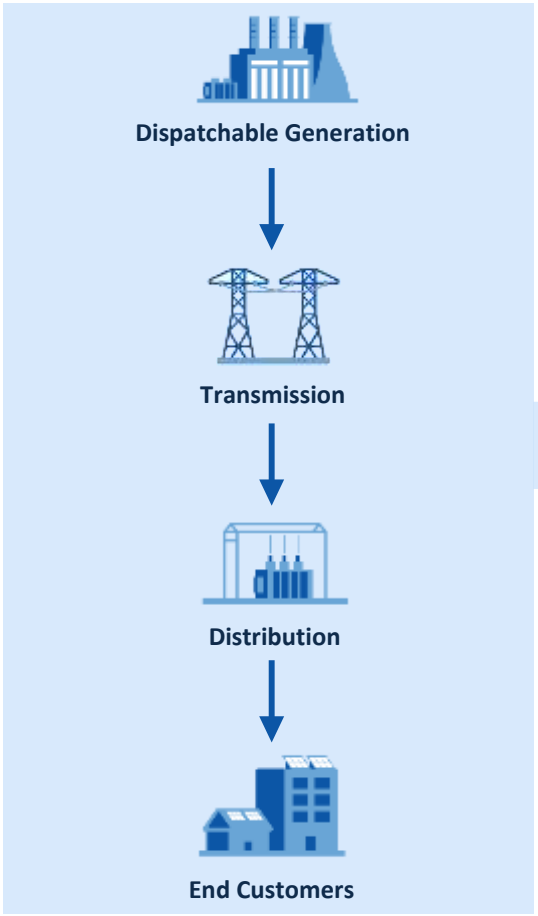
Tomorrow's Decarbonized and Decentralized Power Market

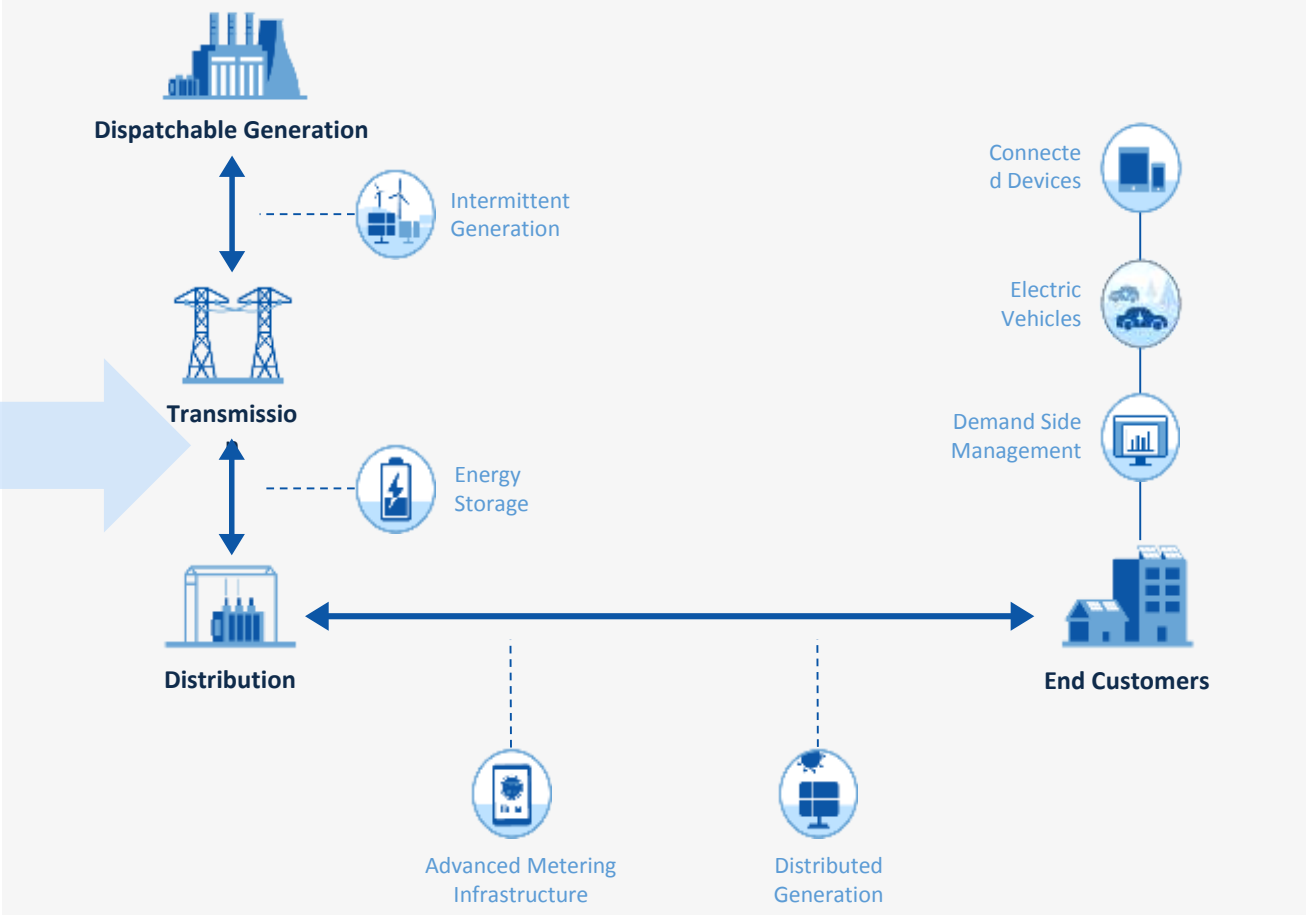
The Power Market of the Past

A top-down, flow from supply to demand



Tomorrow's Decarbonized and Decentralized Power Market

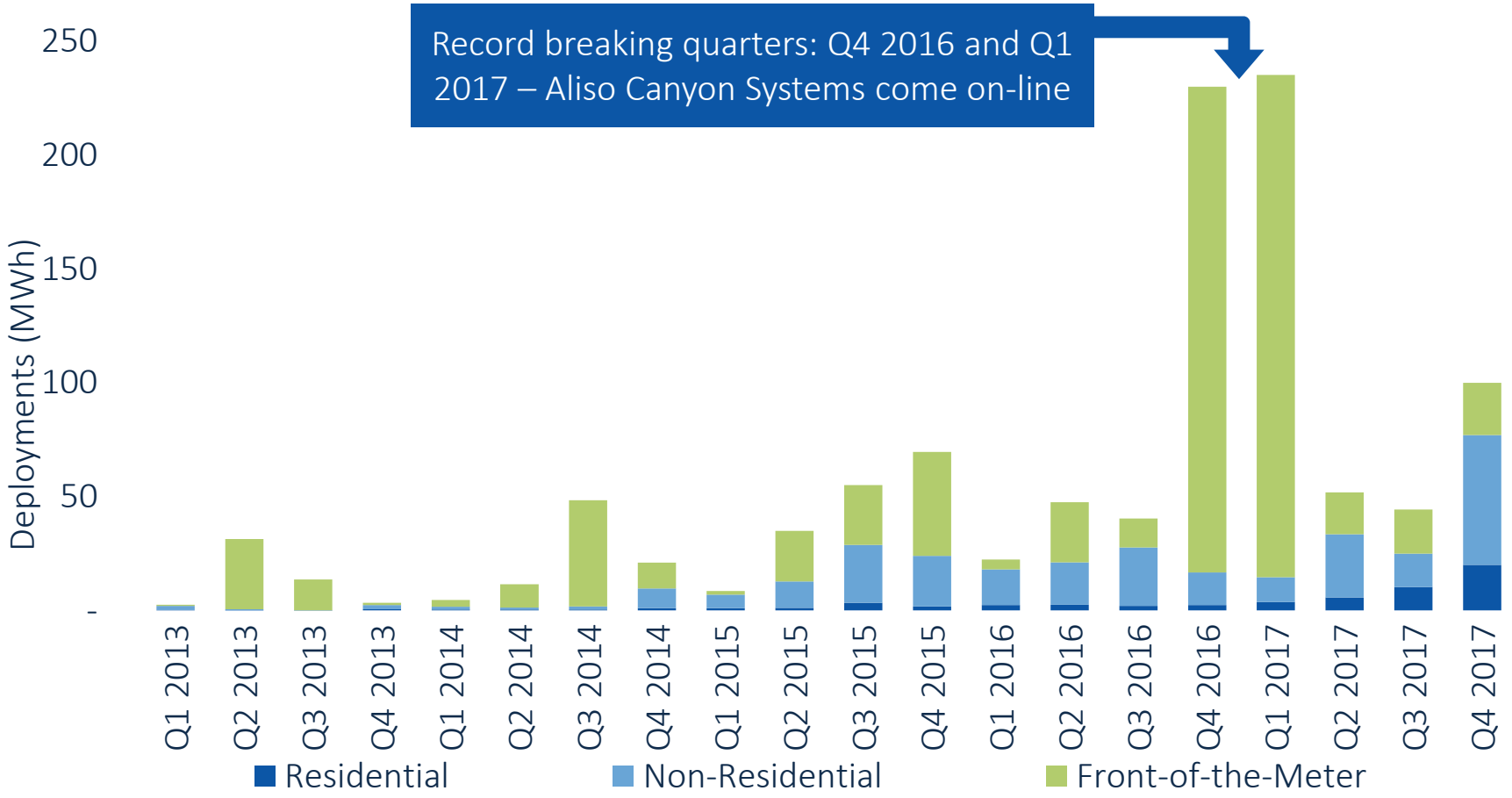
A flatter system with outside market responses and actors at every node reshaping power market planning and operations



1. U.S. Energy Storage Deployment Trends

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

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

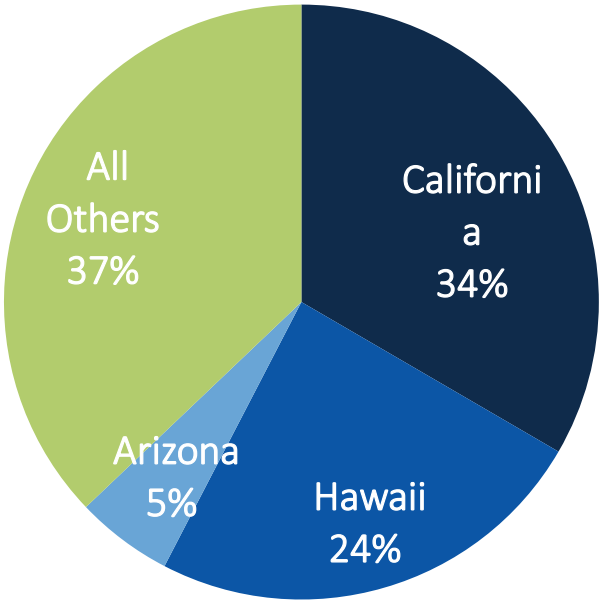


Source: GTM Research/ESA U.S. Energy Storage Monitor

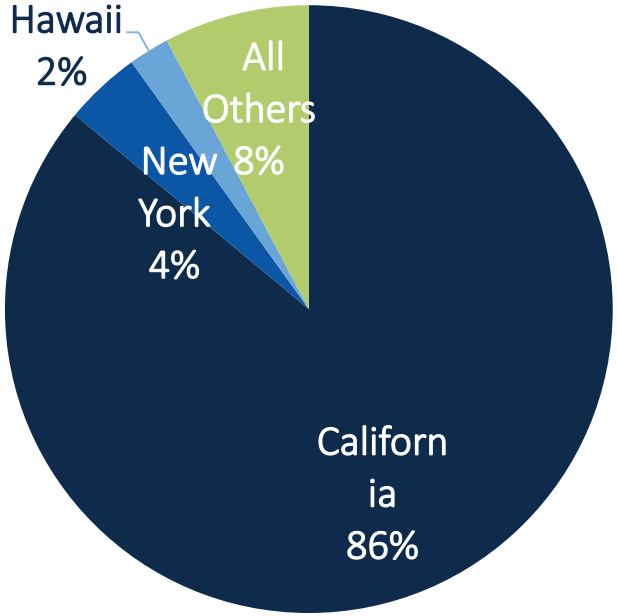
Where Is Energy Storage Deployed So Far? (Megawatt-Hours)

California Accounts for 48% Through 4Q 2017

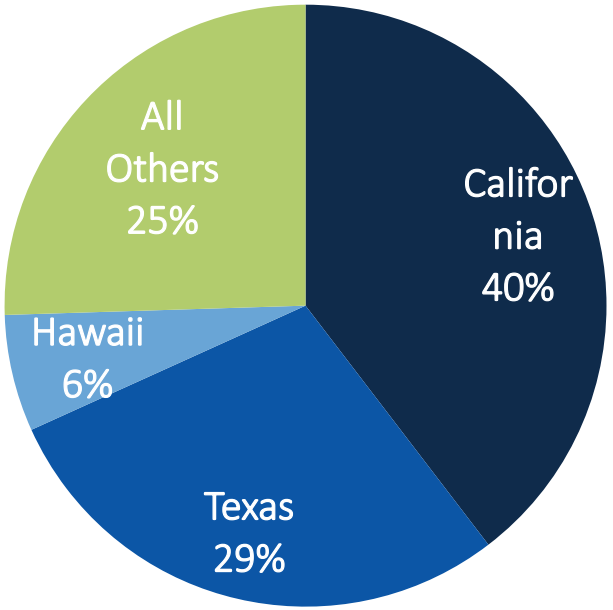
Residential



Non-Residential



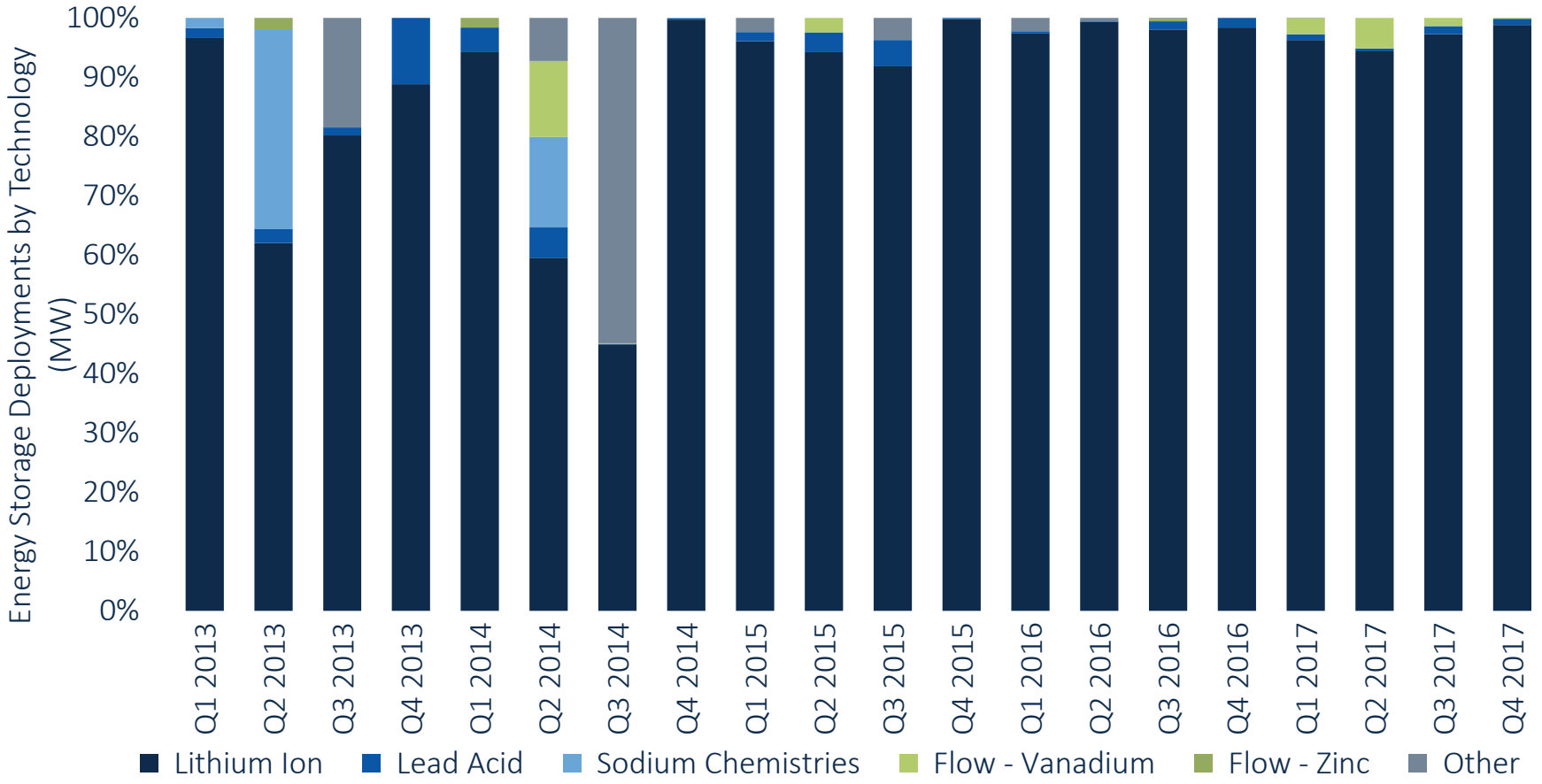
Utility



Source: GTM Research/ESA U.S. Energy Storage Monitor

Lithium-Ion Technology Continues the Trend of More Than 94% Share

Quarterly Energy Storage Deployment Share by Technology (MW %)



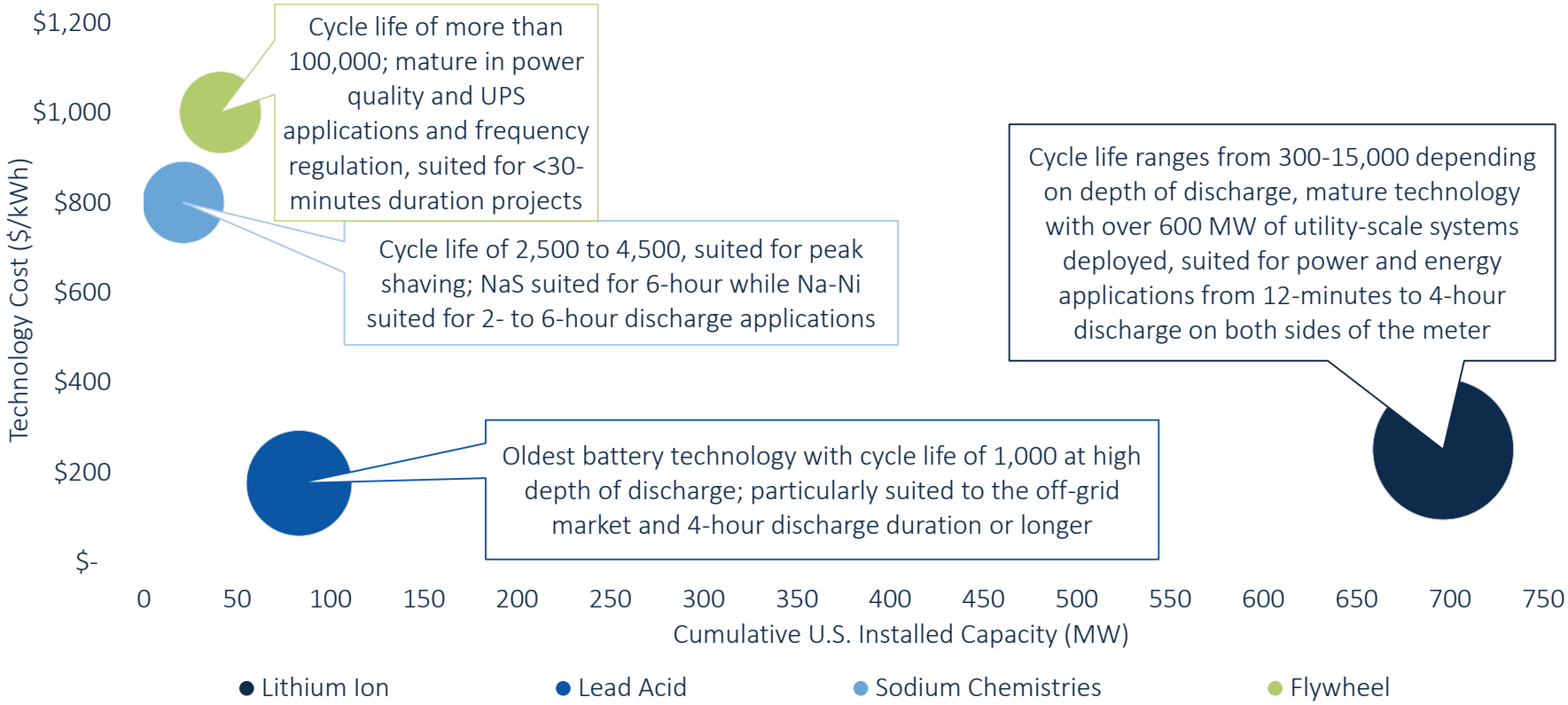
* "Other" includes flywheel and unidentified energy storage technologies.

Source: GTM Research / ESA *U.S. Energy Storage Monitor*

2. Energy Storage Technology and Cost Trends

Commercialized Storage Technologies – Lithium-Ion Off to the Races

Commercialized Energy Storage Technologies: Cost ($/kWh) Versus Cumulative U.S. Installed Capacity (MW)

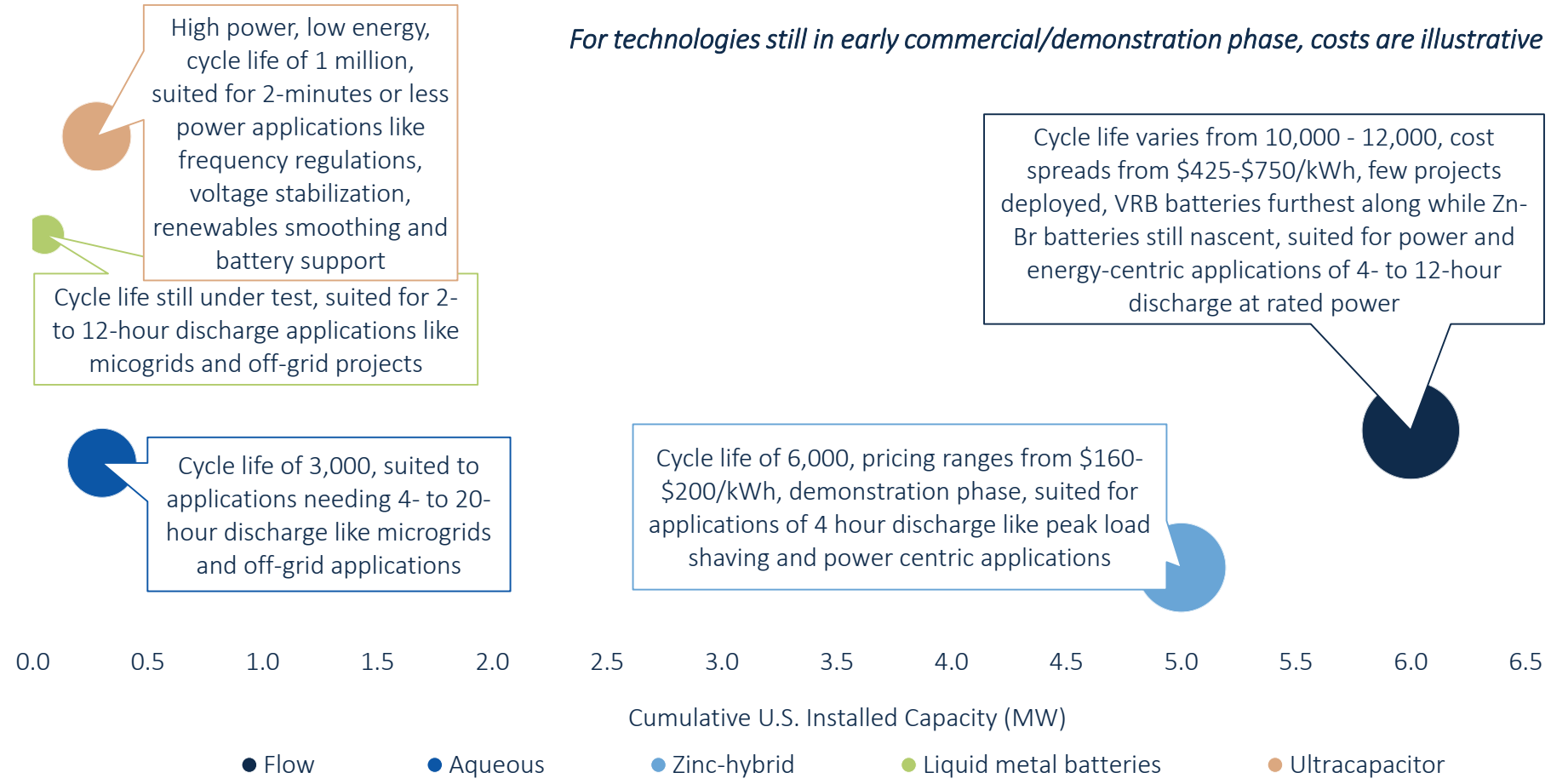


Source: GTM Research / ESA *U.S. Energy Storage Monitor*

Early Stage Storage Technologies – No Clear Winner, Flow Batteries Have Better Prospects

Demonstration/Pilot Phase Energy Storage Technologies: Cumulative U.S. Installed Capacity (MW)

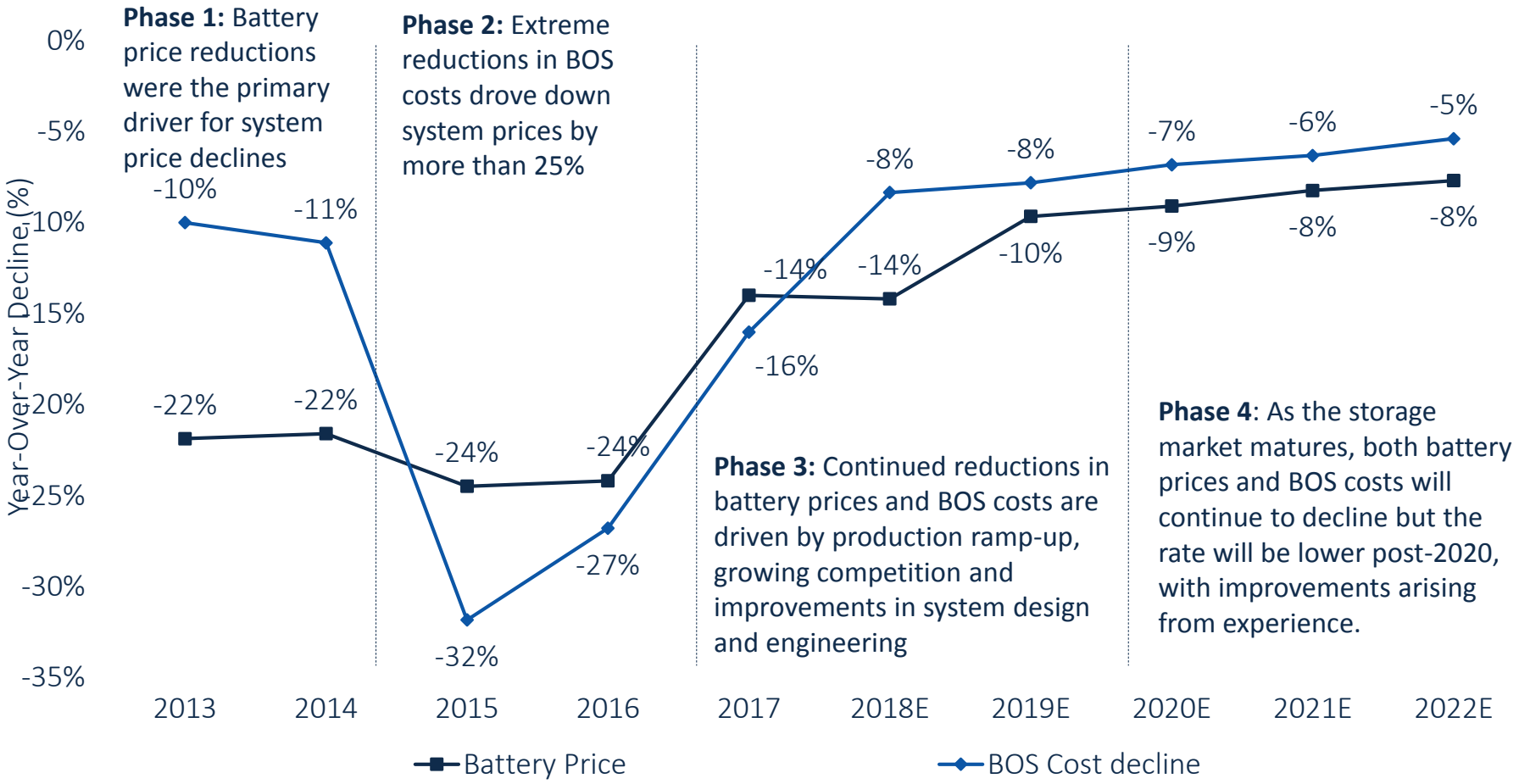
For technologies still in early commercial/demonstration phase, costs are illustrative



Source: GTM Research / ESA *U.S. Energy Storage Monitor*

Annual Declines in Battery Price and Balance-of-System Costs Will Drop Below 10% After 2020

Year-Over-Year Decline in Lithium-Ion Battery Price and BOS Cost, 2013 – 2022E (%)



Source: GTM Research

3. Federal and State Policy Barriers Coming Down

Biggest Shot in the Arm: FERC Rules Energy Storage Must be Eligible to Participate in Wholesale Markets

FERC Order 841

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

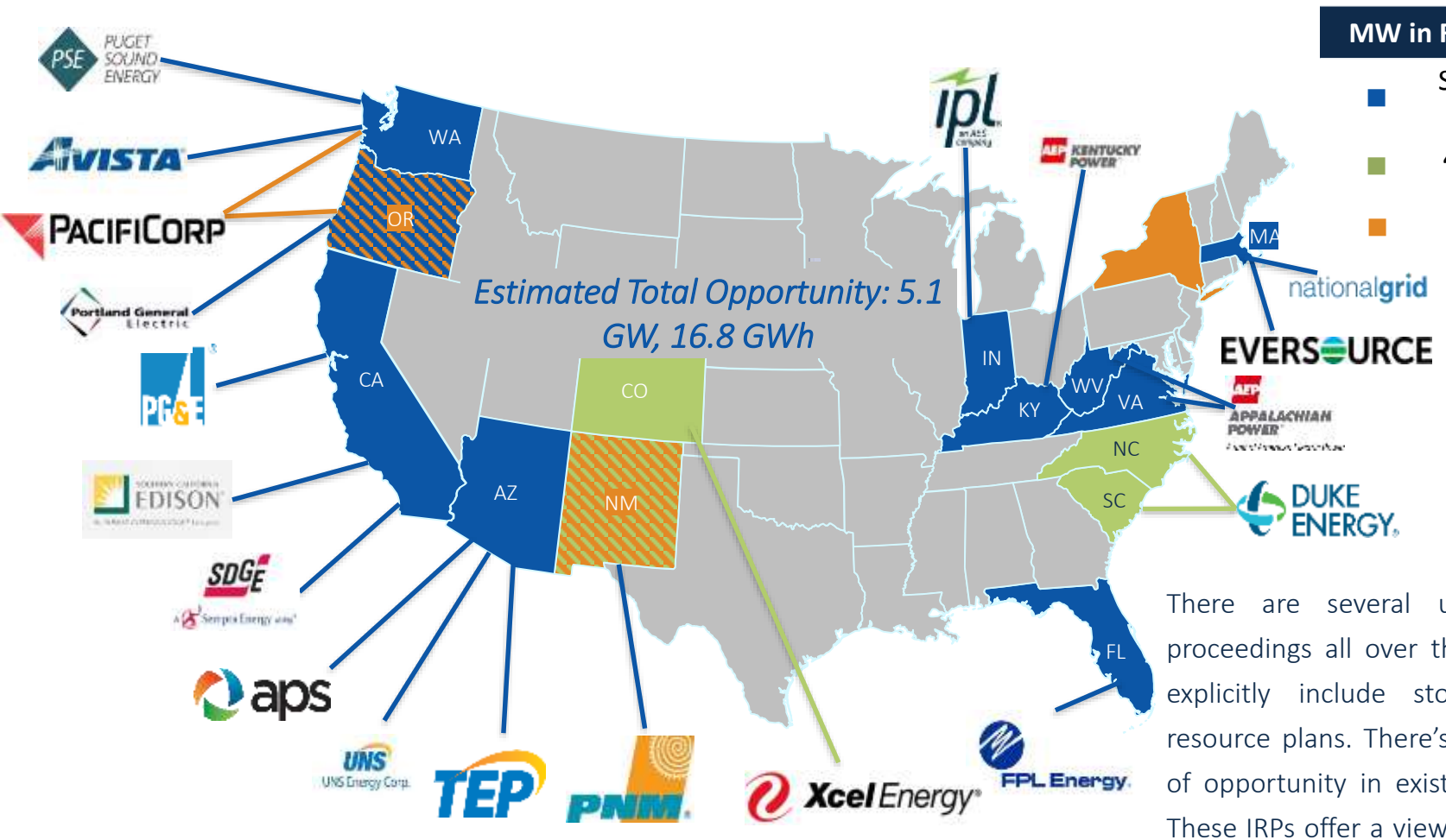
Ensure that a resource using the participation model for electric storage resources can be **dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer** consistent with rules that govern the conditions under which a resource can set the wholesale price.

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**.

Source: GTM Research

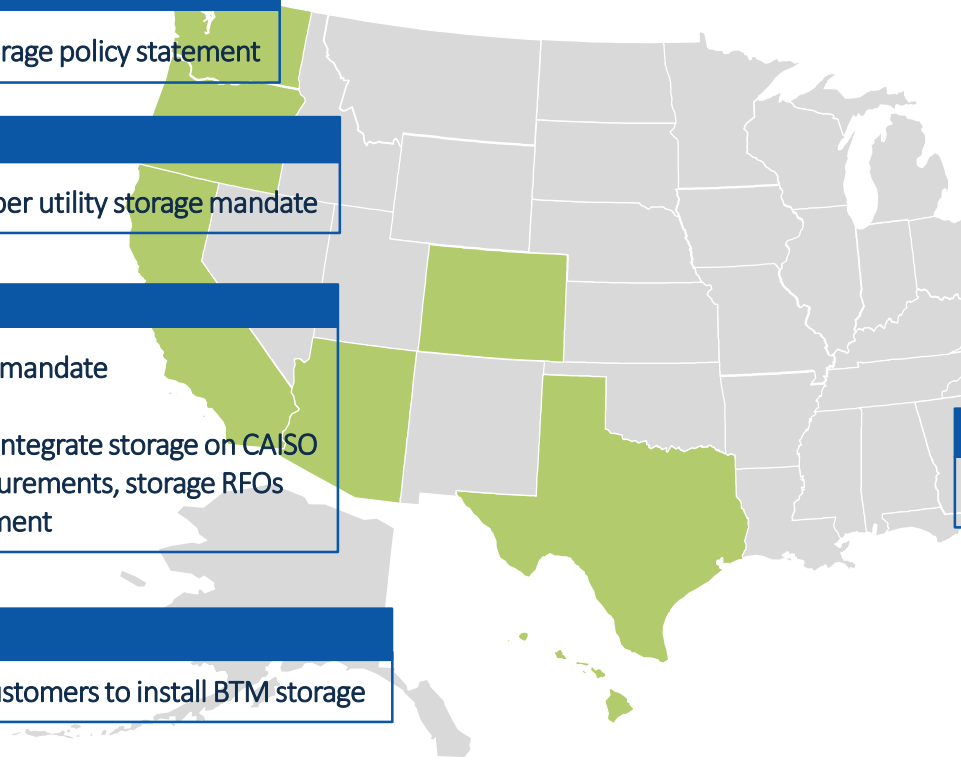
The Momentum Builds: Energy Storage in Integrated Resource Plans
Storage Modeled, Eligible or Mandated in Utility IRPs (MW)



There are several utility resource proceedings all over the country that explicitly include storage in their resource plans. There's about 5.1 GW of opportunity in existing utility IRPs. These IRPs offer a view of storage as a flexible resource on the grid, and complementary, not necessarily a direct threat to CT plants.

Source: GTM Research

Notable State Policies Roundup – Levelling the Playing Field



Washington
- WA UTC energy storage policy statement

Oregon
- Minimum 5 MWh per utility storage mandate

California
- 1,385 MW storage mandate
- SGIP incentive
- ESDER initiative to integrate storage on CAISO
- Local capacity procurements, storage RFOs for peaker replacement

Colorado
- SB18-009 allows customers to install BTM storage

Arizona
- Clean peak standard proposal
- 3 GW energy storage goal proposal

Massachusetts
- 200 MWh energy storage target
- $20 million ACES program
- SMART energy storage adder

New York
- Gov. Cuomo - 1,500 MW goal
- NY REV demo projects
- Con Edison demand management programs

Maryland
- First state with BTM energy storage tax credit

Texas
- Texas PUC initiated rulemaking docket to address energy storage on distribution grid

Hawaii
- First state with innovative solar-plus-storage projects
- Customer solar self-supply tariff

Thank You!

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