U.S. Energy Storage Monitor:
Q4 2017 Full Report

gtmresearch

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A Wood Mackenzie Business

Contents

About This Report

U.S. Energy Storage Monitor is a quarterly publication of GTM Research and the Energy Storage Association (ESA). Each quarter, we gather data on U.S. energy storage deployments, prices, policies, regulations and business models. We compile this information into this report, which is intended to provide the most comprehensive, timely analysis of energy storage in the U.S.

Notes:

- All forecasts are from GTM Research; ESA does not predict future pricing, costs or deployments
- References, data, charts and analysis from this report should be attributed to "GTM Research/ESA U.S. Energy Storage Monitor"
- Media inquiries should be directed to Mike Munsell from GTM Research (munsell@gtmresearch.com) or Ellen Backus with the Energy Storage Association (202.765.2800)

For more information or to purchase the full report, visit www.energystoragemonitor.com.

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Scope of This Report

Capacity Metrics: In general, the electric utility sector uses the term "capacity" to refer to power capacity (i.e., megawatts). We report energy storage capacity and deployments in power capacity (measured in watts) and energy capacity (measured in watt-hours). All of our data sources (details on data sources provided in Appendix), including program administrators, utility companies, utility commissions, and system operators, currently track and report energy storage queue, deployments and interconnections in terms of power capacity: watts, kilowatts or megawatts. GTM Research converts data in energy capacity (watt-hours, kilowatt-hours or megawatt-hours) using a mix of publicly available and survey data, and multiplying by discharge duration (hours). In keeping with industry convention, GTM Research defines capacity in terms of the interconnected power capacity, and not in terms of the flexible resource capability a given storage asset can provide (charging and discharging).

Please note that some projects are publicly announced based on flexible resource capacity. For these projects, the announced capacity may differ from our capacity totals.

Historical Deployment Data: The report is titled "Q4 2017" to reflect the release quarter, but it covers historical deployment data ending Q3 2017. More details on deployment reporting methodology are available in the Appendix.

Segments: We report energy storage capacity data in three segments: residential, non-residential and utility-scale. Projects that are deployed on the end-customer side of the meter (i.e., behind the meter) are reported as falling in either the residential or non-residential segment. The non-residential segment includes commercial, industrial, education, military and nonprofit deployments, but excludes uninterruptible power supply. Regardless of their size, projects that are deployed on the utility side of the meter (i.e., in front of the meter) are reported in the utility-scale segment. In some cases, we differentiate these as "distribution domain" and "transmission domain" to clarify the point of interconnection.

Technologies: Electrochemical (batteries) and electromechanical technologies, excluding pumped hydro, are included in the historical deployment and forecast data.

Market Size: Market size is reported in megawatts (or kilowatts) and megawatt-hours (or kilowatt-hours) of deployments (i.e., interconnected and operational) by year and segment, as well as in U.S. dollars based on system price estimates and annual deployments.

1. Introduction and Key Findings

Q3 2017 U.S. Energy Storage Scorecard

	Q3 2017	Q3 2016	Change
Total Deployments (MWh)	42.5	40.4	Up 5%
Front-of-Meter Deployments (MWh)	19.4	12.7	Up 52%
Behind-the-Meter Deployments (MWh)	23.1	27.7	Down 16%
Total Deployments (MW)	41.8	28.6	Up 46%
Utility-Scale System Price – 2 Hr. ($/kWh)	$$650-$900, median $775	$700-$950, median $800	Down 3%
Utility-Scale Pipeline (MW)	15,230	10,773	Up 41%
Cumulative Five-Year Forecast (MW)	7,438	5,593	Up 33%

Recapping the U.S. Energy Storage Market in Q3 2017

The U.S. energy storage market saw modest quarter-over-quarter growth in megawatt terms, with 41.8 MW deployed in Q3 2017.

The utility-scale segment saw notable recovery: After a low Q2 (22 MW), the market recovered to 30.9 MW in Q3 2017 thanks to a single large project in Texas (30 MW). Integrated resource plans will form a cornerstone of this market's future (a deeper analysis of these policies can be found in Section 3).

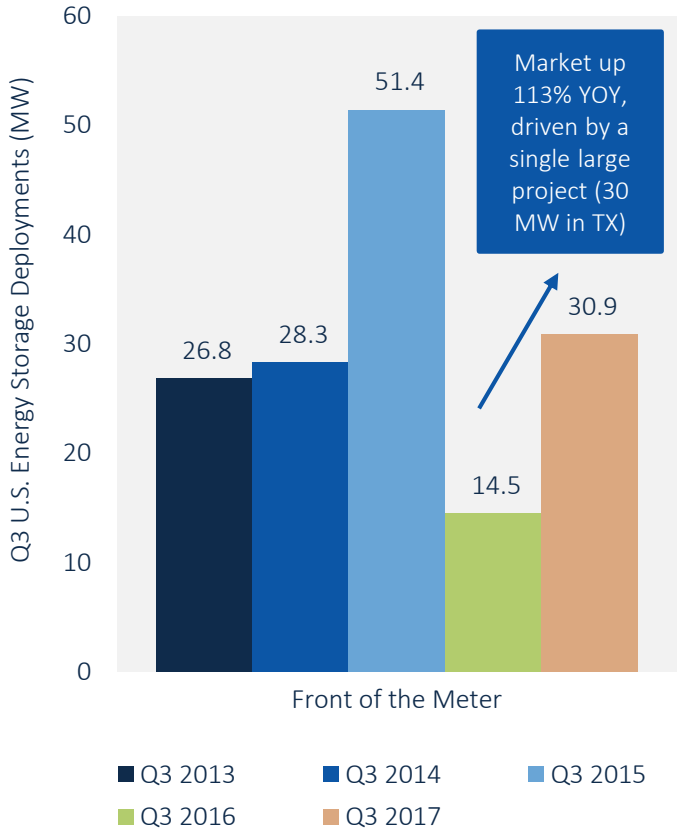
Meanwhile, the behind-the-meter market fell 32% from Q2, with 11 MW deployed in Q3 2017 vs. last quarter's 16.2 MW; however, this fact comes wholly from a softening in the non-residential market in California, as the residential market saw significant growth quarter-over-quarter and a record 4.2 MW from a massive 730 deployments. Non-residential players in California are awaiting incentive reservations and payouts from the Self-Generation Incentive Program, which have seen longer timelines than initially expected. Meanwhile, the residential market has attracted great interest in both California and Hawaii, where improving economics are driving more widespread adoption among customers.

On the venture capital and project finance front, total investments in the first three quarters of 2017 have already passed total investments for 2016, meaning this year will see growth. The largest deal in Q3 2017 came from a $34.7 million investment in Advanced Microgrid Solutions. While Q3 itself saw no M&A activity, it's notable that October and November 2017 saw some key deals: Enel announced the acquisition of EV charging specialist eMotorWerks and Trane announced the acquisition of thermal storage vendor Calmac.

2. Energy Storage Market Overview

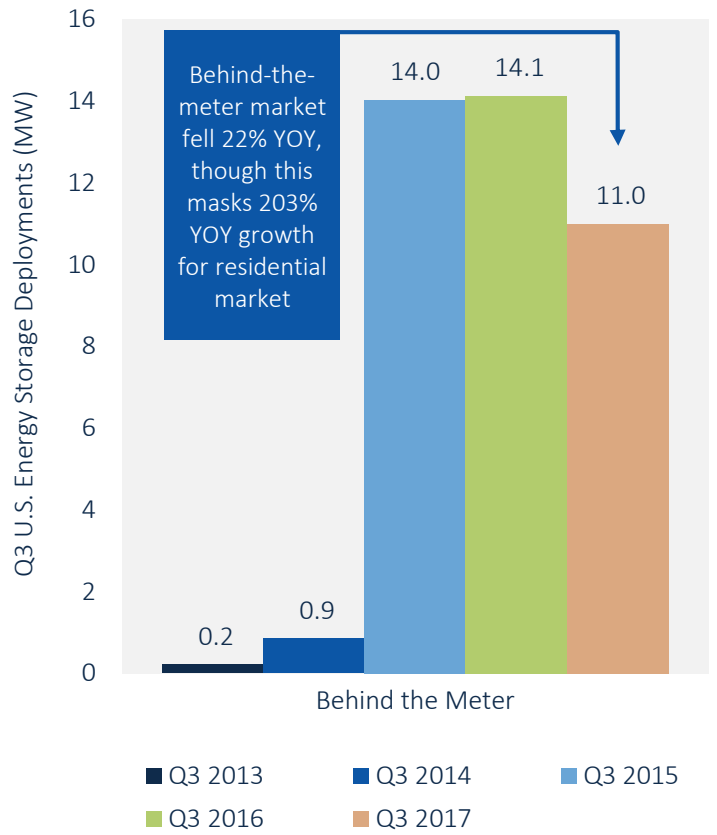
The U.S. Deployed 42 MW of Energy Storage in Q3 2017

Front of Meter



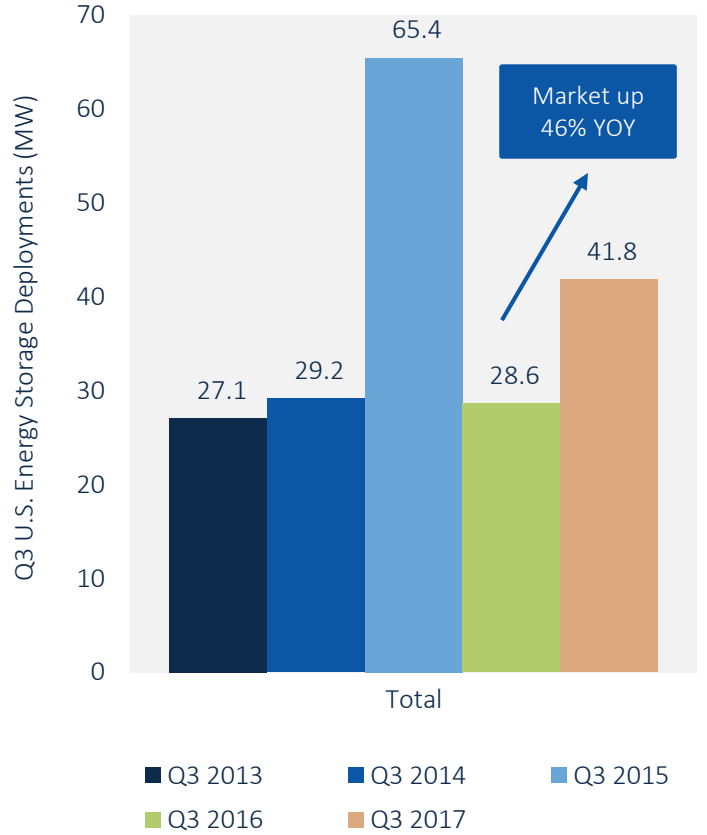
Source: GTM Research

Behind the Meter



Source: GTM Research

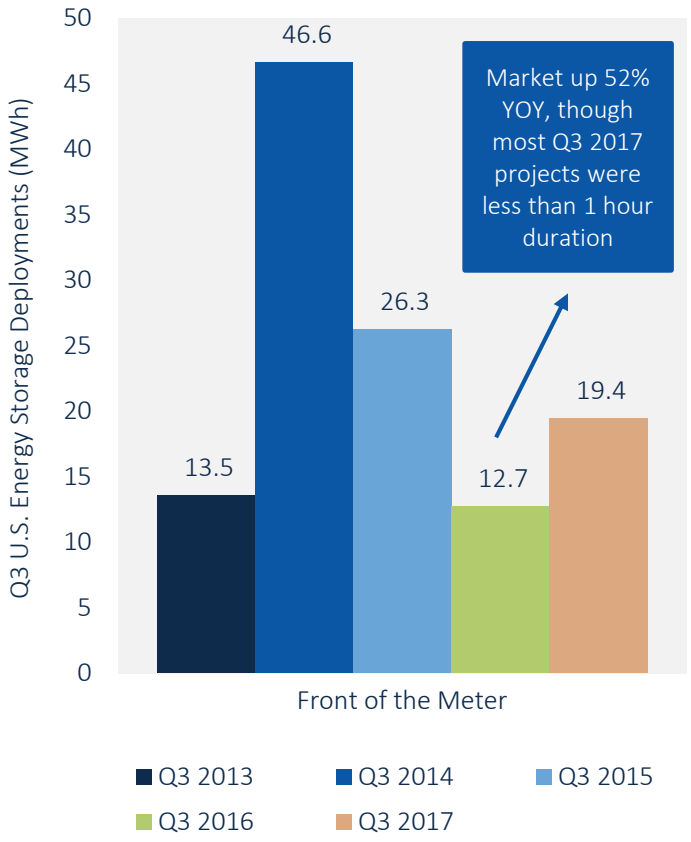
Total



Source: GTM Research

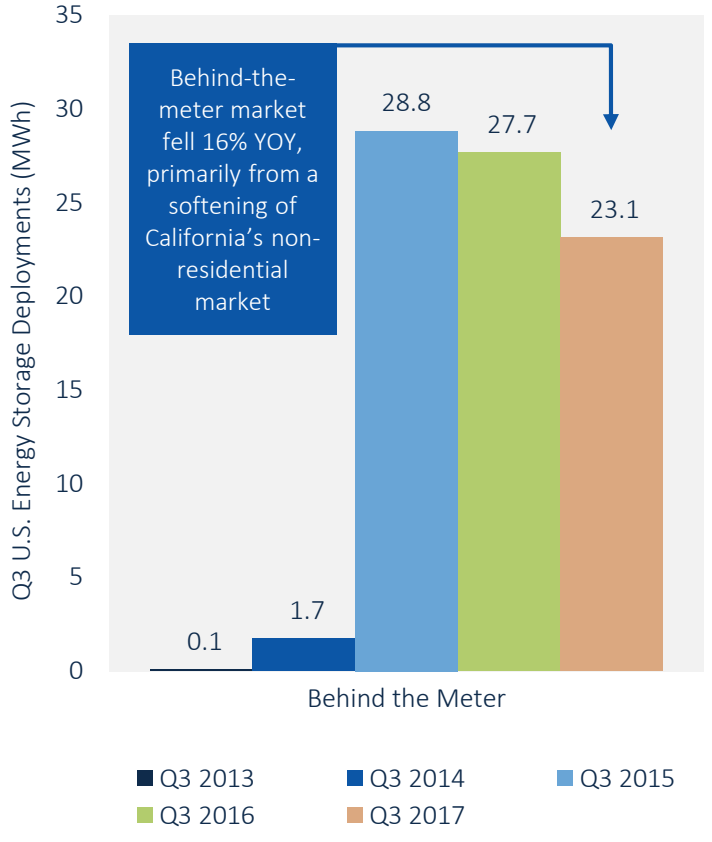
The U.S. Deployed 43 MWh of Energy Storage in Q3 2017

Front of Meter



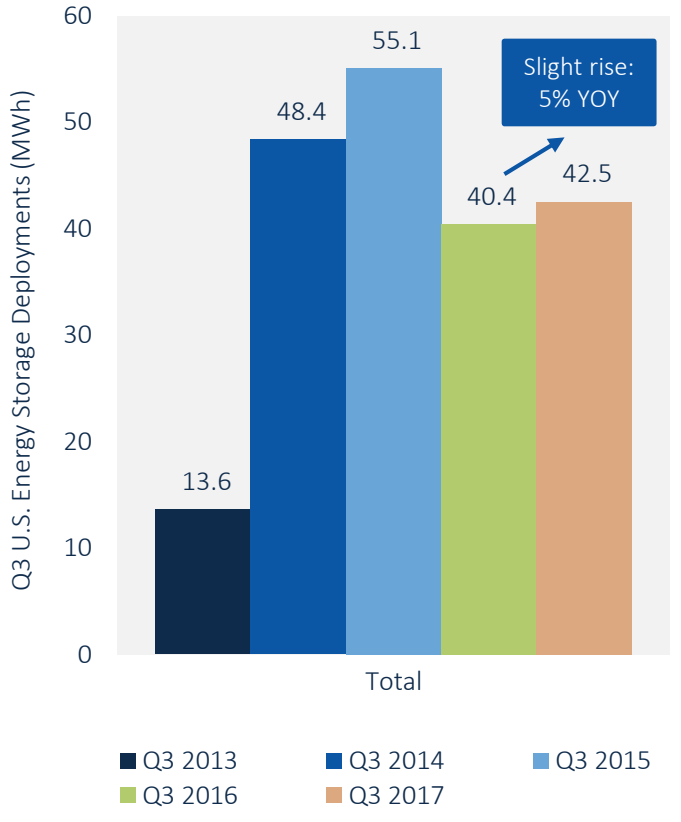
Source: GTM Research

Behind the Meter



Source: GTM Research

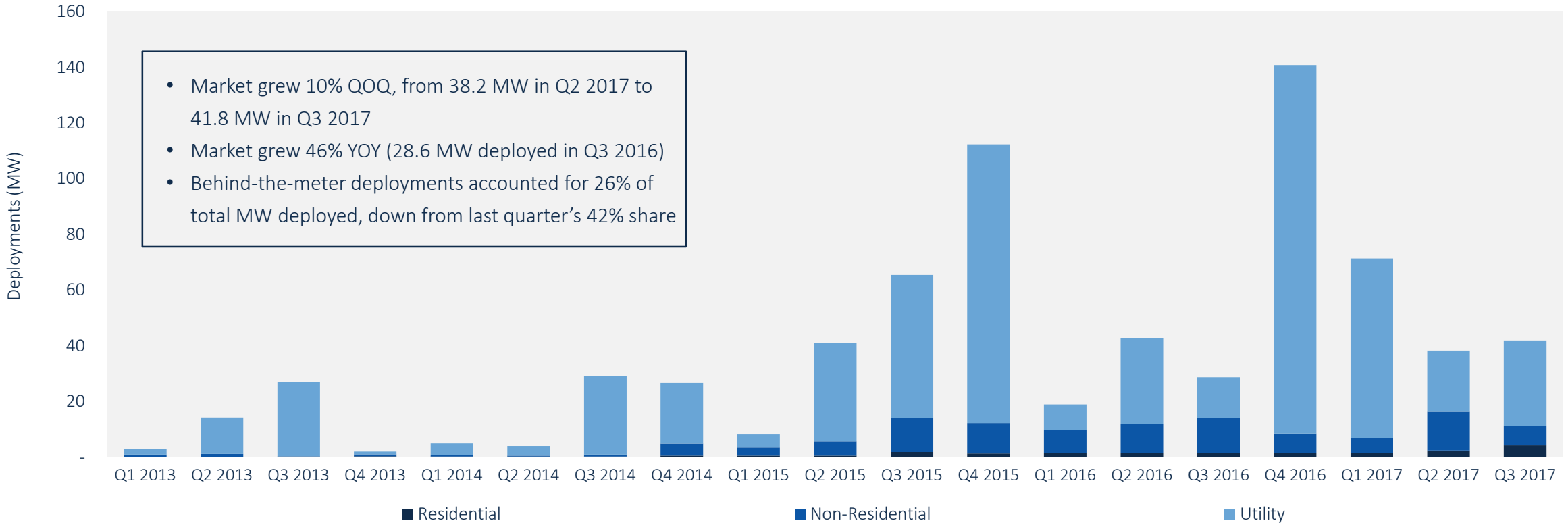
Total



Source: GTM Research

U.S. Q3 2017 Deployments in Megawatts Up 46% Over Previous Year

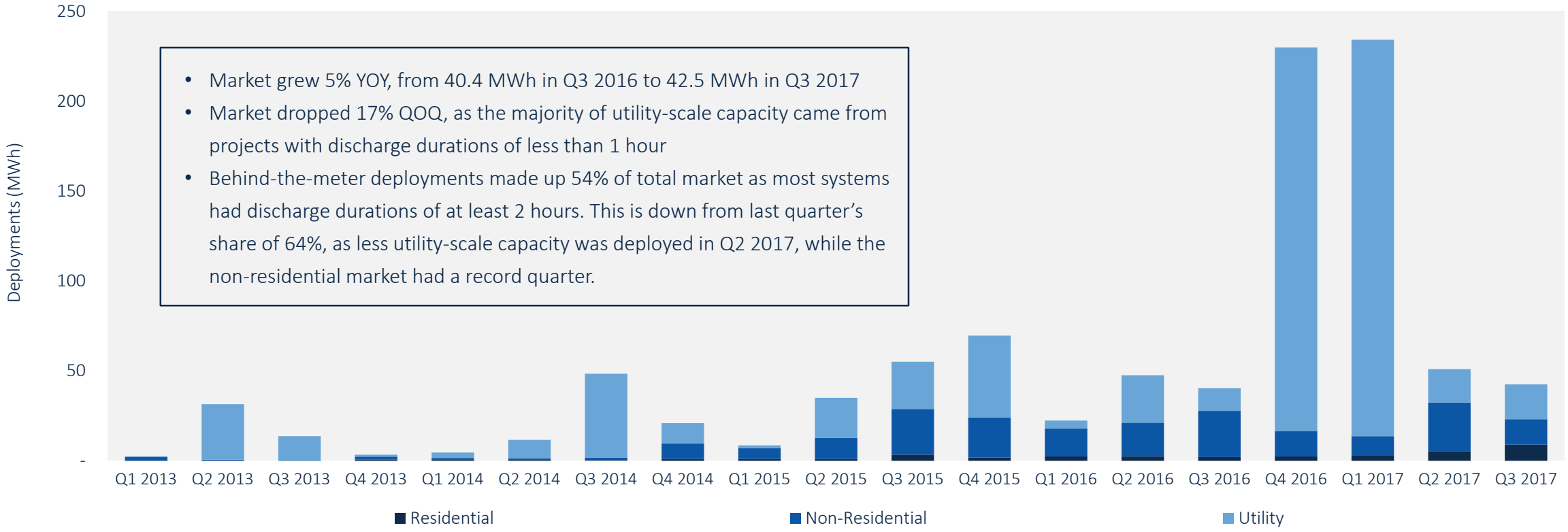
U.S. Quarterly Energy Storage Deployments by Segment (MW)



Source: GTM Research

U.S. Q3 2017 Deployments in Megawatt-Hours Up 5% Over Previous Year

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

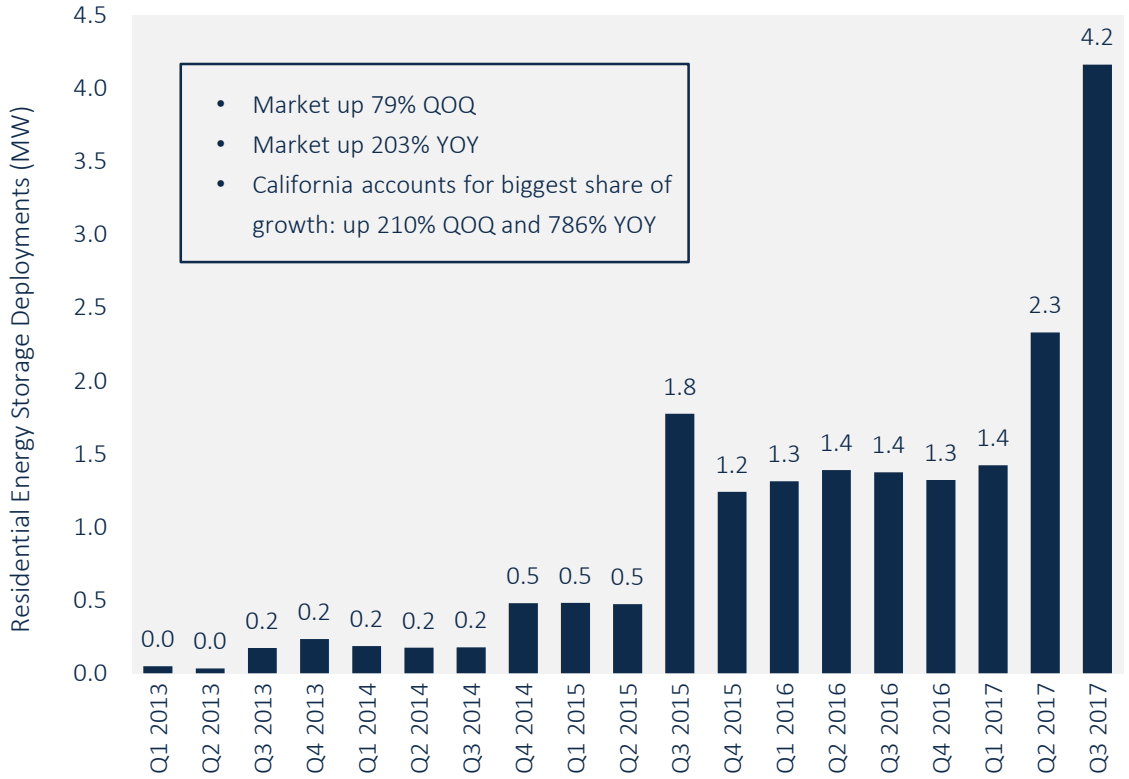


- Market grew 5% YOY, from 40.4 MWh in Q3 2016 to 42.5 MWh in Q3 2017
- Market dropped 17% QOQ, as the majority of utility-scale capacity came from projects with discharge durations of less than 1 hour
- Behind-the-meter deployments made up 54% of total market as most systems had discharge durations of at least 2 hours. This is down from last quarter's share of 64%, as less utility-scale capacity was deployed in Q2 2017, while the non-residential market had a record quarter.

Source: GTM Research

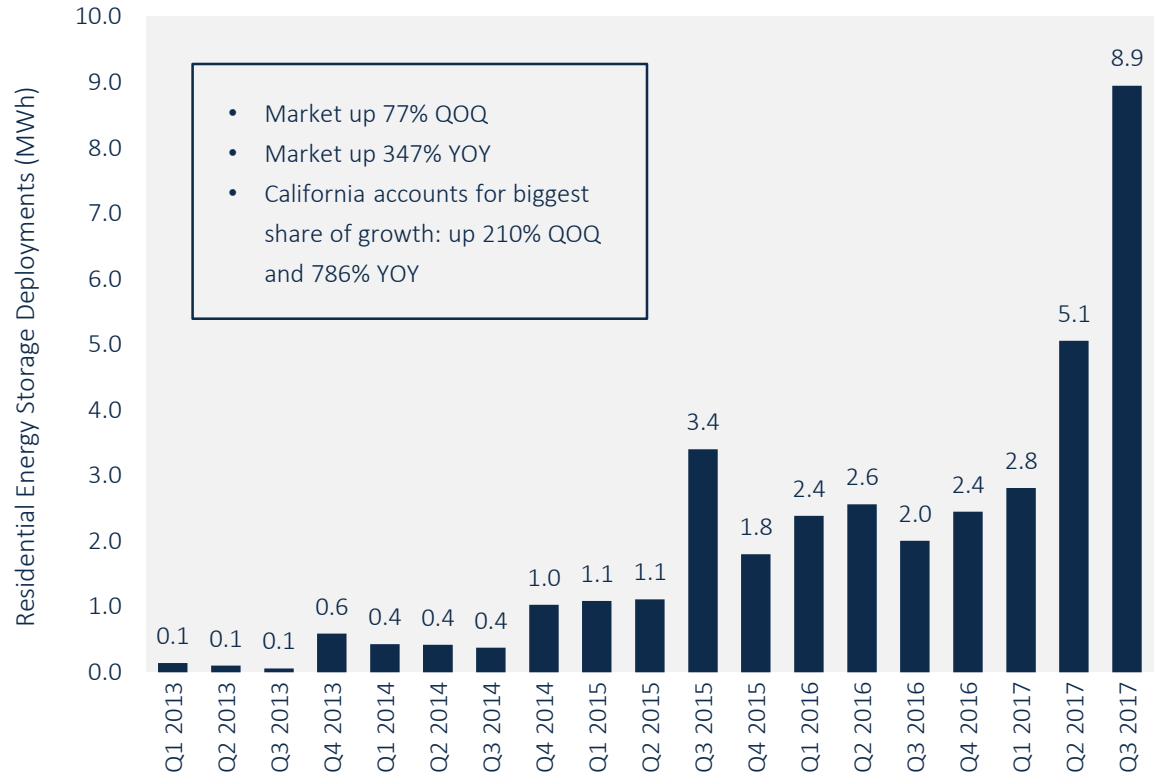
Residential Market Grows More Than 77% QOQ, Led by California and Hawaii

Residential Market (MW)



Source: GTM Research

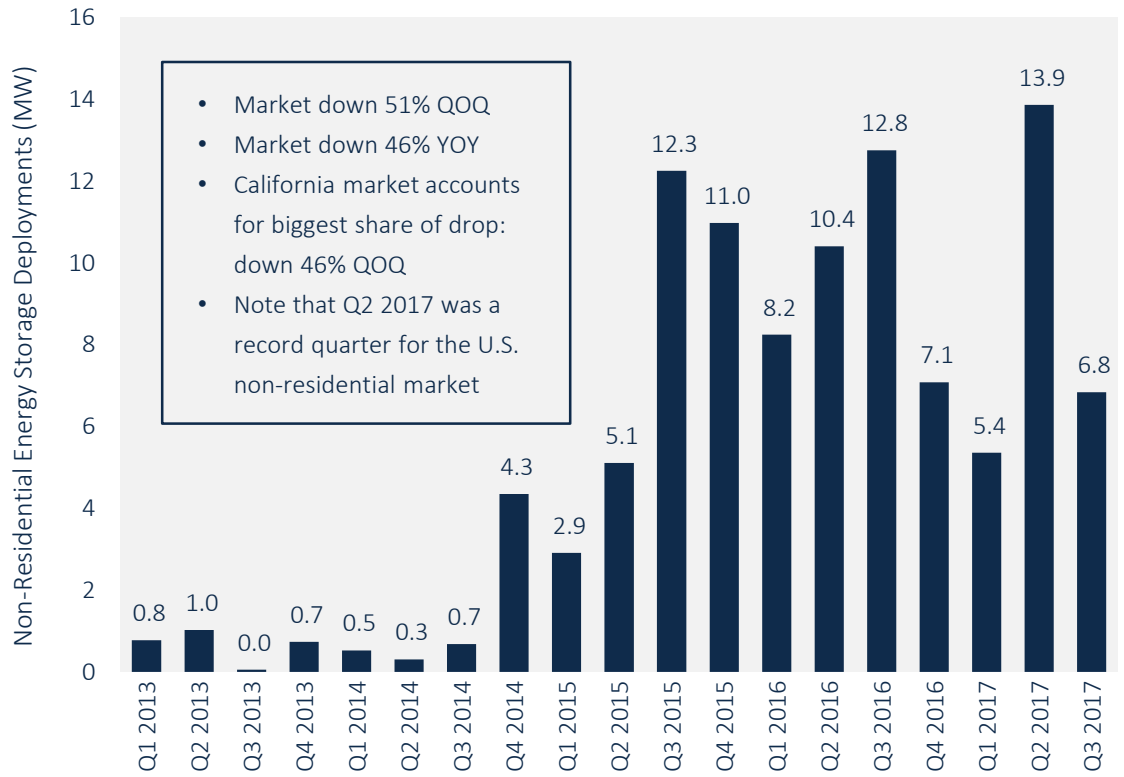
Residential Market (MWh)



Source: GTM Research

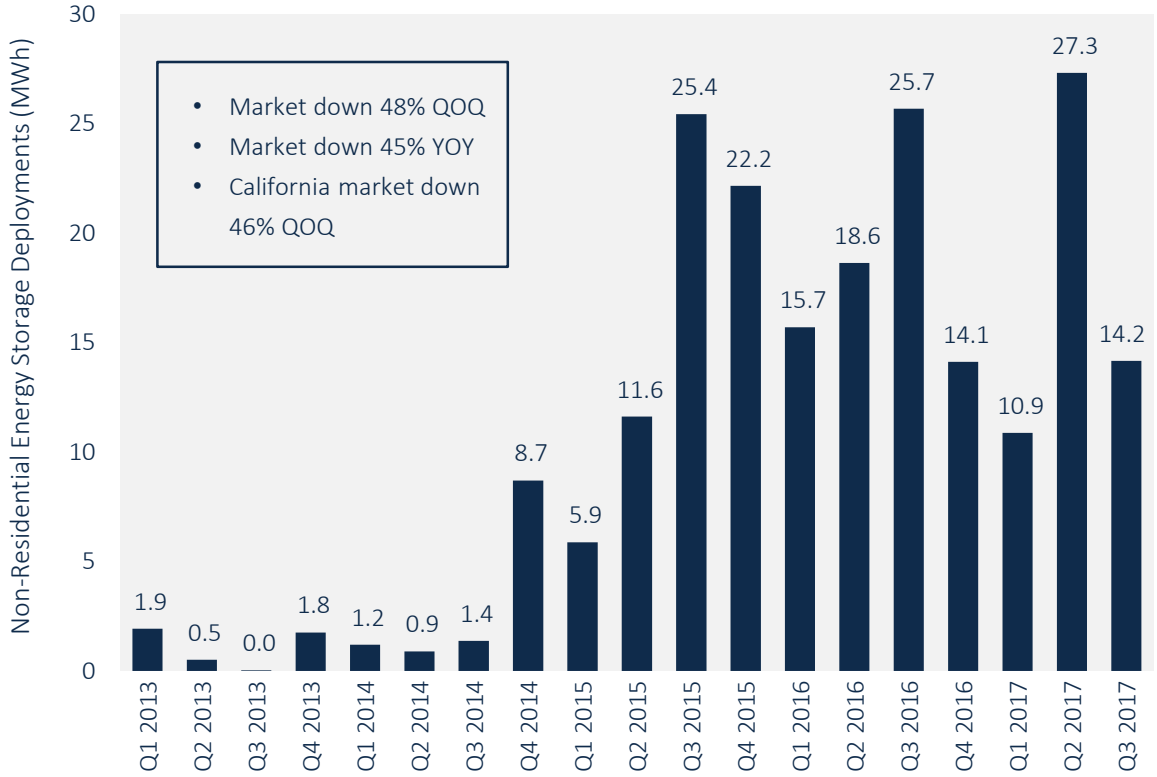
Non-Residential Market Halves QOQ as California Market Awaits Next Installation Wave

Non-Residential Market (MW)



Source: GTM Research

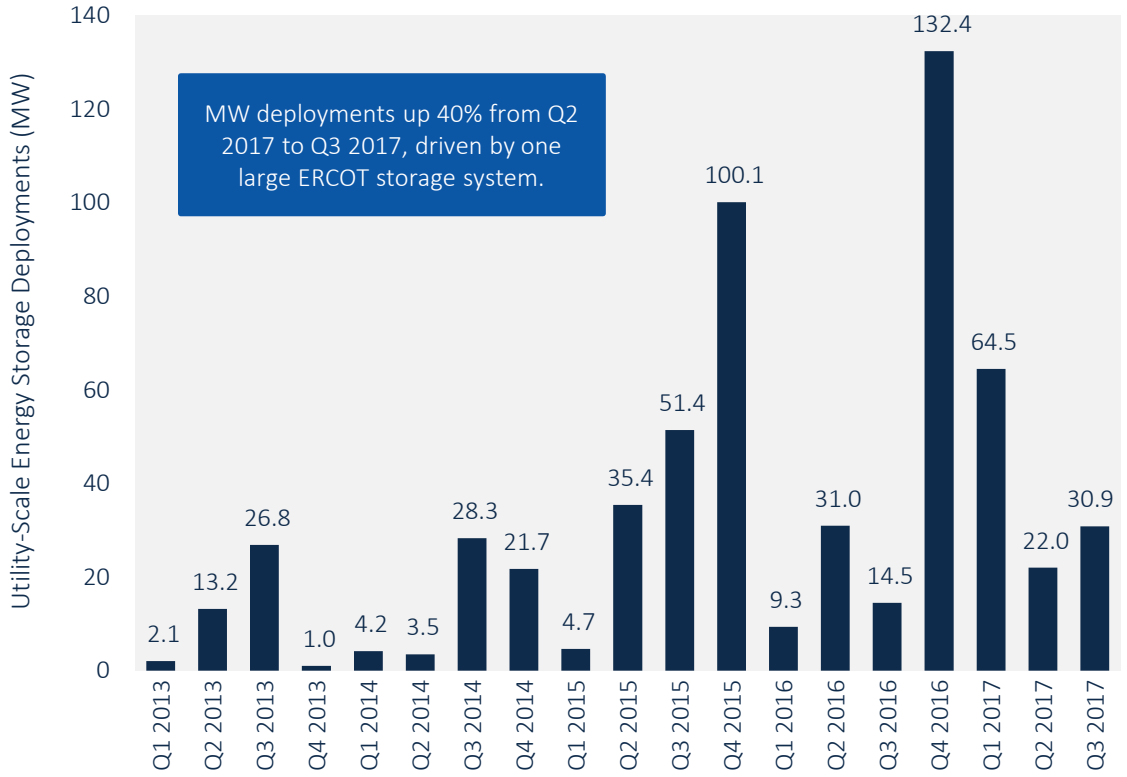
Non-Residential Market (MWh)



Source: GTM Research

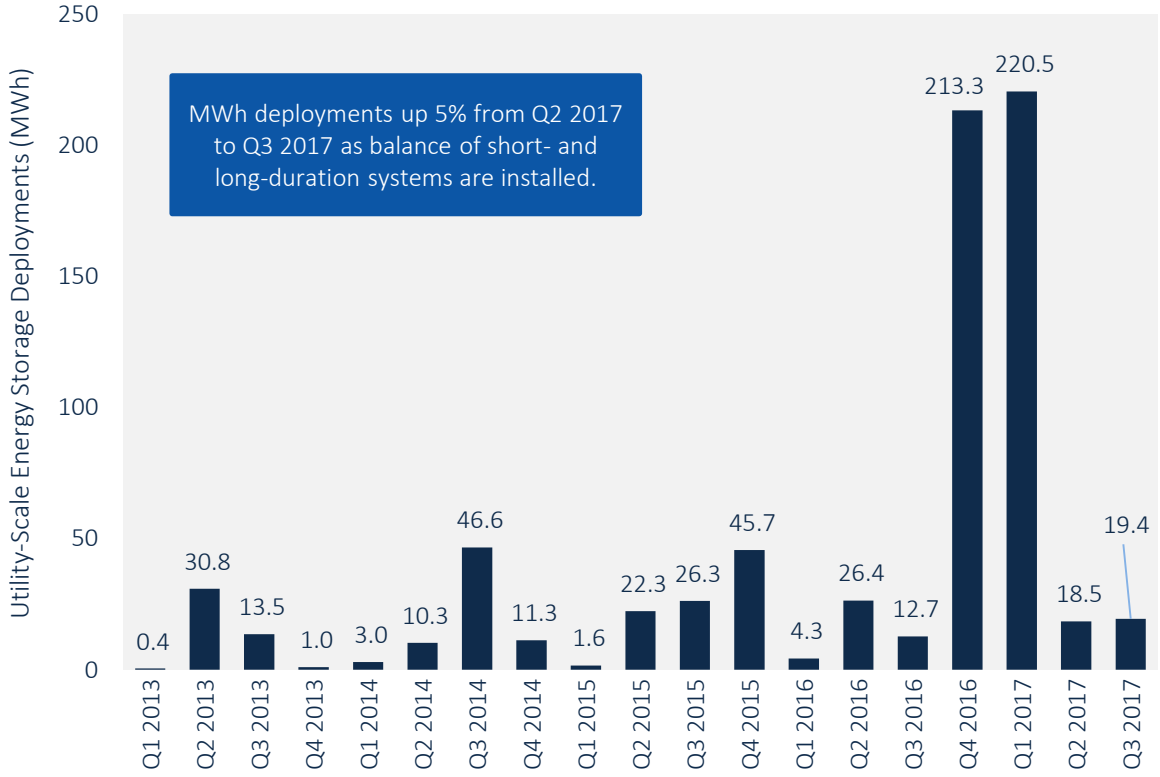
Utility-Scale Market

Utility-Scale Market (MW)



Source: GTM Research

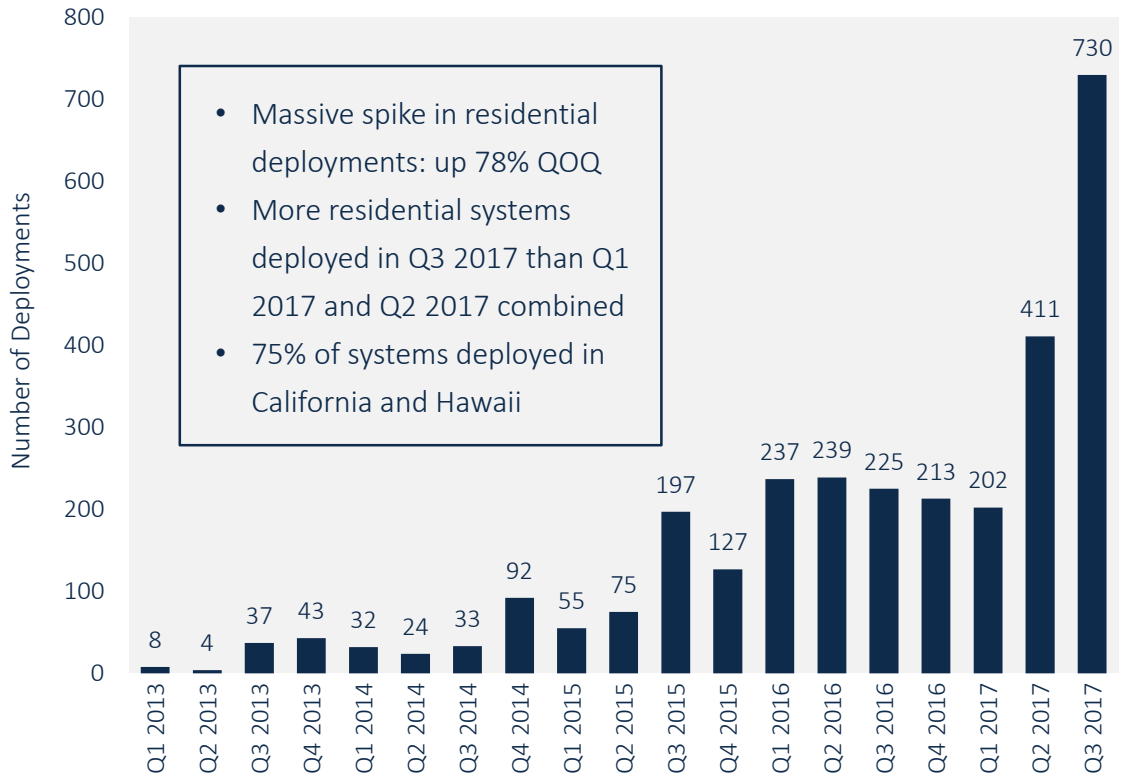
Utility-Scale Market (MWh)



Source: GTM Research

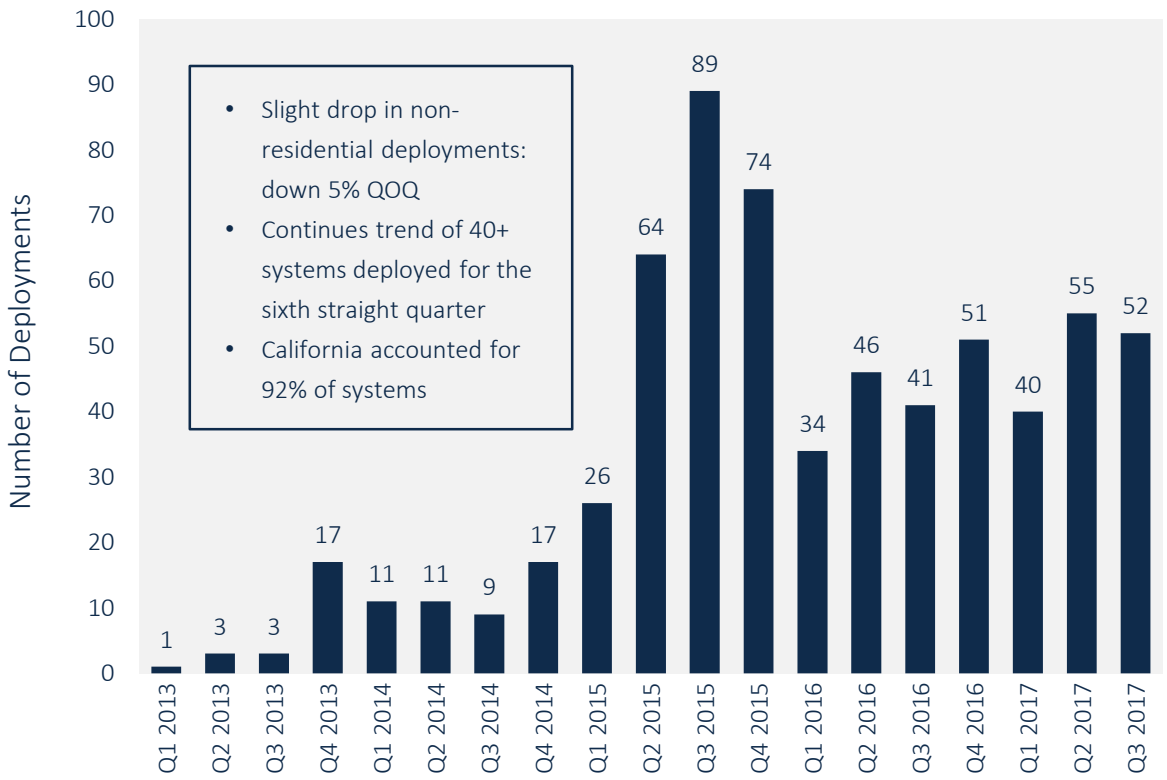
Behind-the-Meter Segment Saw a Record 782 Deployments

Residential Market (Number of Deployments)



Source: GTM Research

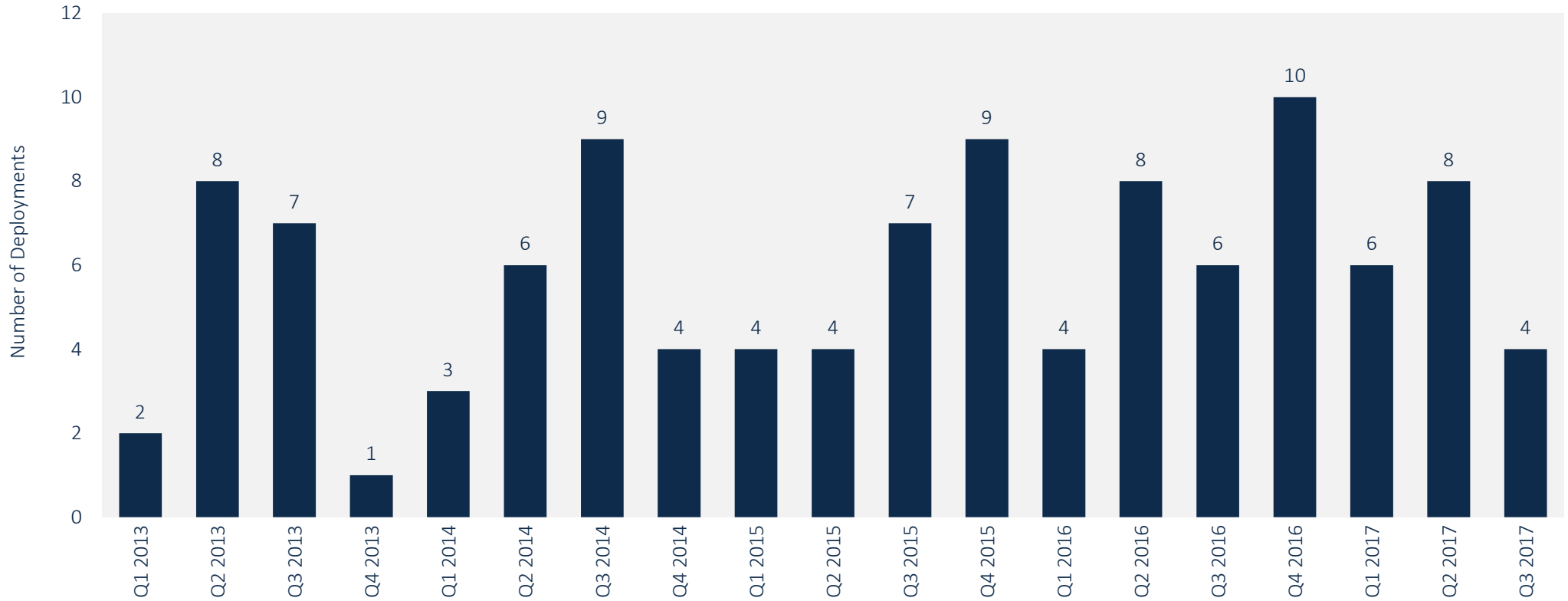
Non-Residential Market (Number of Deployments)



Source: GTM Research

Utility-Scale Deployments

Utility Market (Number of Deployments)



Only 4 utility-scale projects were fully deployed in Q3 2017, the lowest since Q1 2016. Front-of-the-meter deployments remain comparably uncommon, making it difficult to identify any quarterly trends or spikes for deployments.

Source: GTM Research

Top Energy Storage Markets, Q3 2017: Texas Leads Utility-Scale, California Dominates BTM

Top 3 Markets by Segment in Q3 2017 (Power Capacity)

Rank	Residential	Deployments (kW)
1	California	1,870
2	Hawaii	1,218
3	All Others*	728

Rank	Non-Residential	Deployments (kW)
1	California	6,544
2	All Others*	285
3	Hawaii	5

Rank	Utility	Deployments (MW)
1	Texas	30.0
2	Massachusetts	0.5
3	All Others*	0.4

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

- California and Hawaii remain the residential market leaders, with the former deploying 1.9 MW and the latter deploying 1.2 MW in Q3 2017, both setting records. Much of Calif.'s deployments were a direct result of the Self-Generation Incentive Program, while the latter saw growth from the Customer Self-Supply program.
- California's non-residential throne remains unchallenged in Q3 2017, with 6.5 MW deployed (96% market share). The "Other Markets" category saw significant activity, with deployments in a variety of states and regions including Connecticut (Northeast), Florida (Southeast) and Oregon (Northwest).
- Texas led the utility-scale market with a single 30 MW project, accounting for 97% of megawatts deployed in Q3 2017. Massachusetts, Tennessee and Florida saw deployments as well to round out the quarter.

Source: GTM Research

Top Energy Storage Markets' Cumulative Deployments Since Q1 2013

Top 3 Markets by Segment, Q1 2013-Q3 2017 (Power Capacity)

Rank	Residential	Deployments (kW)
1	All Others*	6,193
2	California	5,816
3	Hawaii	4,052

Rank	Non-Residential	Deployments (MW)
1	California	89.9
2	All Others*	4.2
3	New York	3.6

Rank	Utility	Deployments (MW)
1	PJM (excl. NJ)	260.3
2	California	158.6
3	All Others*	89.3

Rank	Total	Deployments (MW)
1	PJM (excl. NJ)	262.6
2	California	254.3
3	All Others*	99.7

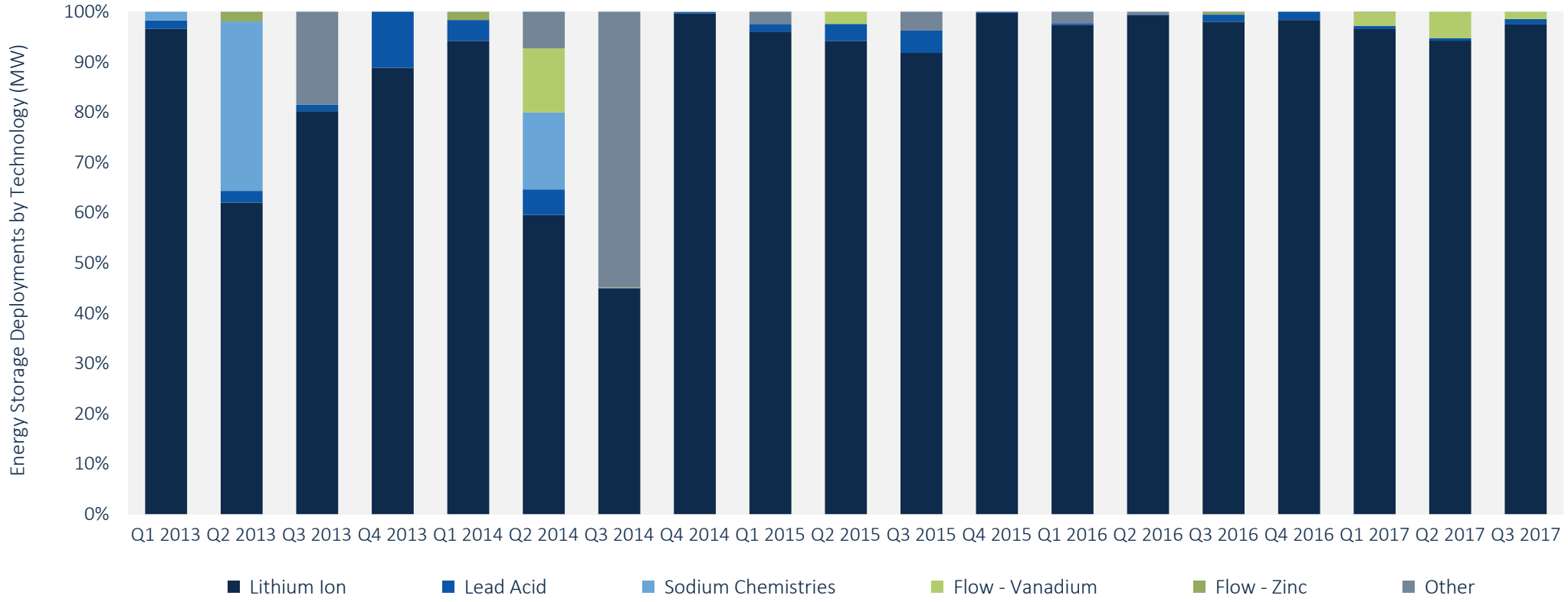
* GTM Research is currently monitoring eight individual markets: Arizona, California, Hawaii, Massachusetts, New Jersey, New York, PJM and Texas.

- Decreasing market share held by PJM (excl. New Jersey) and California continued in Q3 2017, dropping to 20%. Q2 2017 saw a combined market share of 44%, down from the trend of these two markets having a combined market share of more than 50%, which occurred in all quarters except one since Q1 2014. As the PJM market has dried up considerably for utility-scale systems, this trend is expected to continue, though California will remain a strong market.
- California's iron grip on the non-residential market shows no signs of abating. To date, California accounts for 86% of total non-residential megawatts deployed, greatly bolstered by the Self-Generation Incentive Program (SGIP). With non-residential systems set to come on-line for programs like Local Capacity Requirements and Preferred Resources Pilot over the next three years, this trend will doubtless continue, though there is an opportunity for other states to take a larger share of the pie as non-residential demand-charge management and grid services opportunities mature.
- California remains the single state leader for residential deployments, with Q3 2017's influx from the newest iteration of the SGIP solidifying this position. Hawaii is a close second as systems under Customer Self-Supply continue to be deployed.
- With few projects installed in Q3 2017, the rankings for front-of-the-meter storage markets changed little, with PJM continuing to hold the top spot. Texas rose in the rankings, but has yet to gain enough market share to place it among the top three. California will surpass PJM in the near future, as the former has a large queue of projects expected to be deployed while the latter's market opportunities have evaporated.

Source: GTM Research

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

Quarterly Energy Storage Deployment Share by Technology (MW %)



Lithium-ion held 97.5% market share in Q3 2017, leading the market for the 12th quarter straight

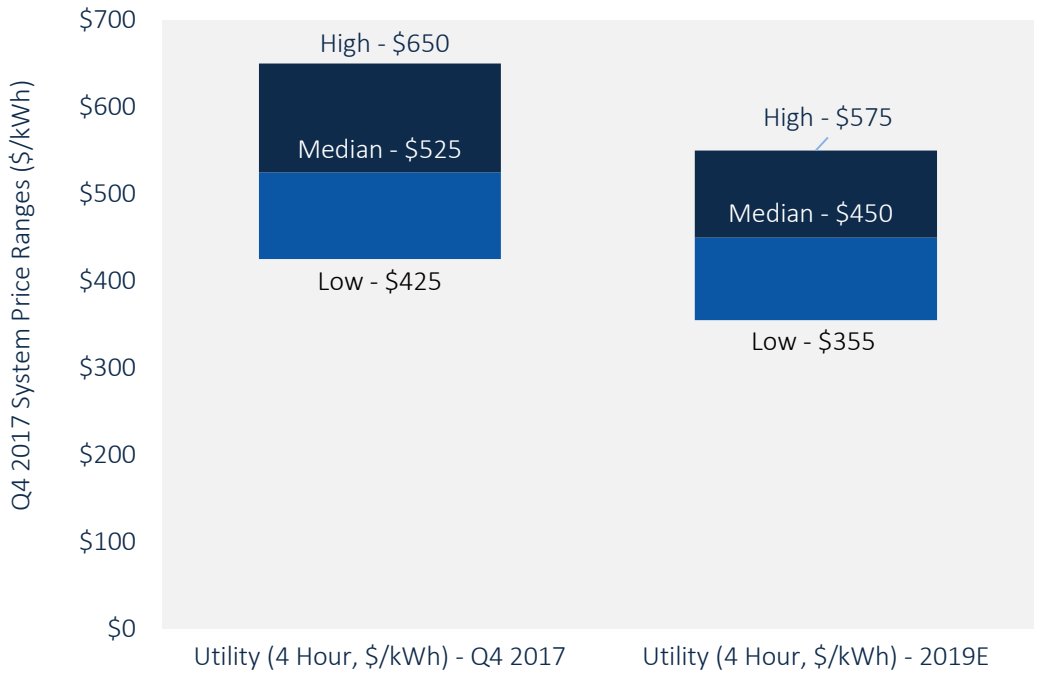
Lead-acid had 1.1% market share, followed closely by vanadium redox flow with 1%

Source: GTM Research

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

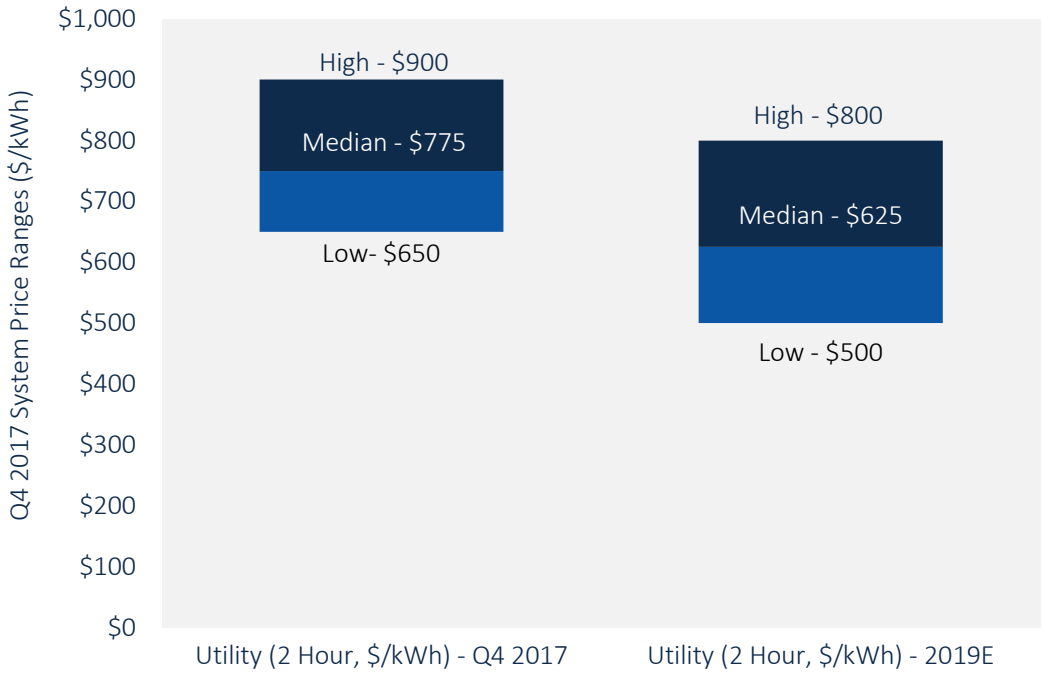
Front-of-the-Meter System Price Trends in Q4 2017

Utility-Scale Price Trends Q4 2017 and 2019E, 4-Hour ($/kWh)



Source: GTM Research

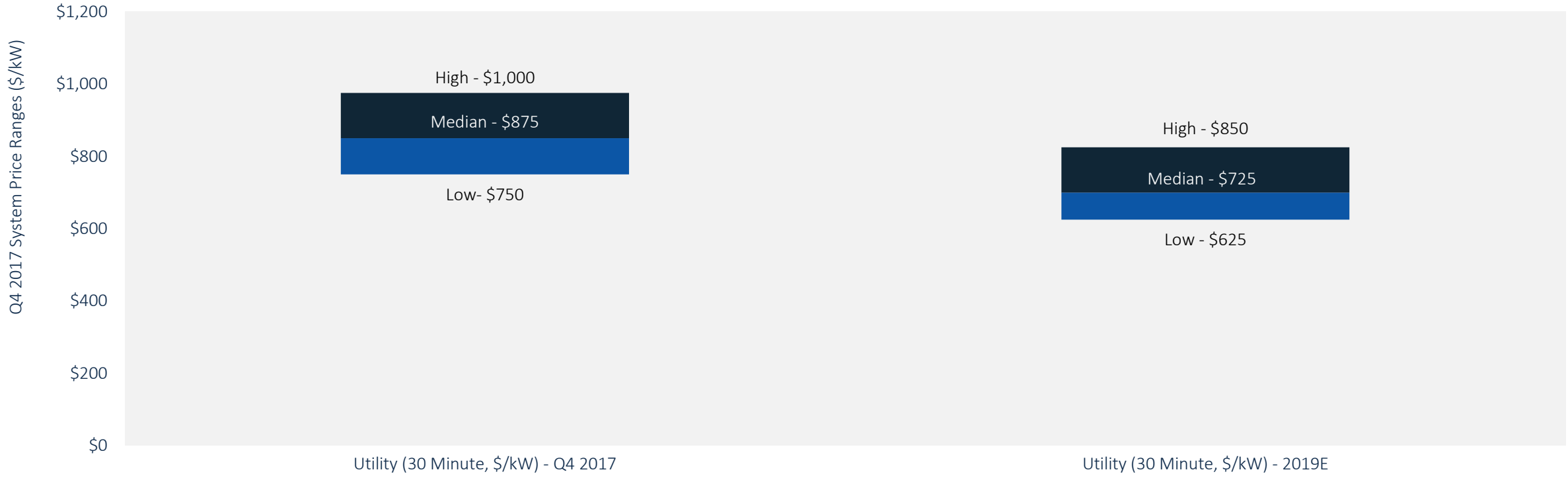
Utility-Scale Price Trends Q4 2017 and 2019E, 2-Hour ($/kWh)



Source: GTM Research

Front-of-the-Meter System Price Trends in Q4 2017 (Cont.)

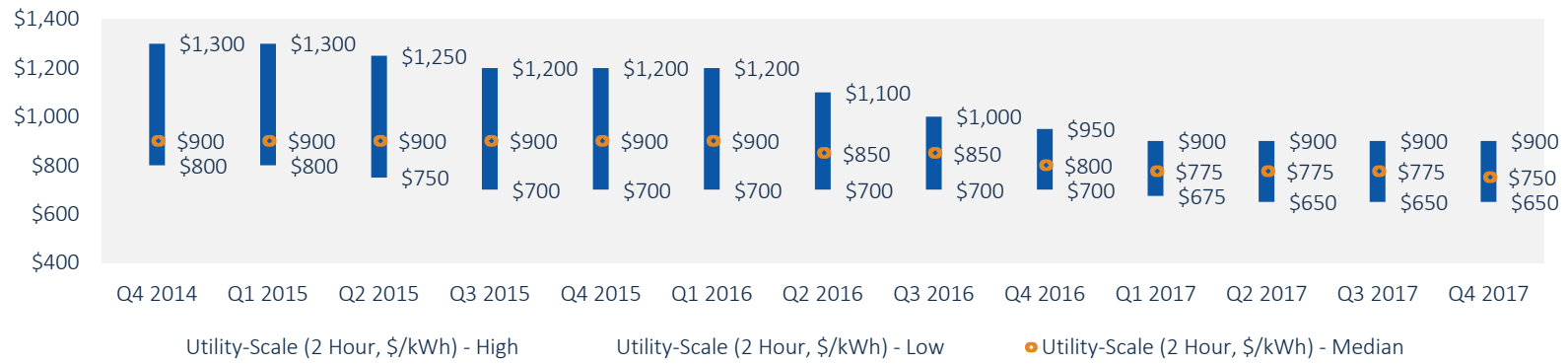
Utility-Scale Price Trends Q4 2017 and 2019E, 30-Minute ($/kW)



Source: GTM Research

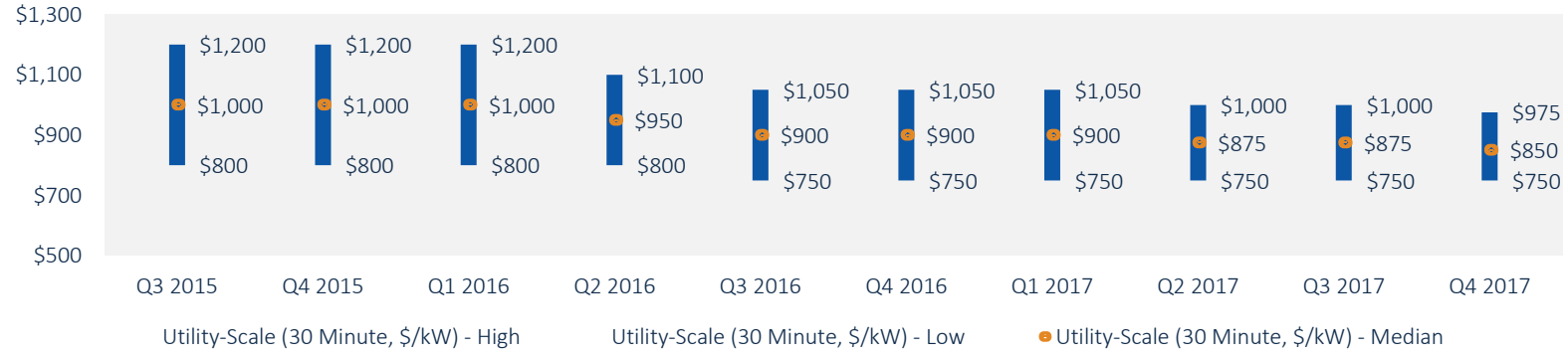
Historical System Price Trends: Front-of-the-Meter Prices Down

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



Source: GTM Research

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



Source: GTM Research

- Utility-scale systems deployed for energy applications (2-hour discharge duration) have experienced consistent price declines since late 2014. Median system prices declined 6% from Q4 2016 to Q4 2017.
- Utility-scale systems deployed for power applications (30-minute discharge duration) have experienced less significant price declines, driven mainly by the stagnation in PJM's RegD market and the subsequent decline in short-duration projects. A recent surge in short-duration systems in other frequency regulation markets, however, has corresponded to newly dropping prices. These systems experienced a 5% median price decline from Q3 2016 to Q3 2017.
- Note that GTM Research has only tracked costs in $/kW for utility-scale systems since Q3 2015.
- With few new projects coming on-line in the utility segment in the past several months, prices have held relatively steady quarter-to-quarter.

Front-of-the-Meter System Price Trends in Q4 2017

Front-of-the-meter system prices dropped slightly in Q4 2017 for power application systems. Over the past several quarters, systems have been deployed for frequency regulation in several markets, allowing more visibility for short-duration system prices. System prices for energy applications also dropped slightly in Q4 2017, as more detailed information on several projects getting installed over the next few months has begun to become available. It should be emphasized that system prices do not change linearly with discharge duration, as several non-battery components (including soft costs) scale with kilowatts or megawatts, while batteries and container costs are typically quoted in $/kWh.

Further system-price decreases are anticipated for future quarters, enabled by higher contracted deployment volumes and driven by the following factors:

- Reduction in battery-pack costs, including batteries, wiring, racking and battery management systems. These have contributed to the largest system-cost reductions in recent months.
- Improvements in system integration, required to get batteries running with power conversion systems and the grid.
- Reduction in balance-of-system costs, more recently driven by improvements in engineering, procurement and construction costs.
- These prices are not associated with specific projects being deployed in Q3 2017, since pricing data is considered sensitive by vendors and developers, given the number of projects that are being deployed and the varying project cycles. This system-price data is instead estimated for projects deployed today based on the results of the bottom-up cost survey from 18 interviews with vendors across the value chain, including battery vendors, system integrators and developers.

For front-of-the-meter applications, we track three types of systems:

- 4-hour applications: Used for longer-duration applications such as capacity, pricing associated with discharge duration of 4 hours and system sizes of 10 MWh to 120 MWh
- 2-hour applications: Used for longer-duration applications such as time-shifting, pricing associated with discharge duration of 2 hours and system sizes of 1 MWh to 10 MWh
- Power applications: Used for short-duration applications such as frequency regulation, pricing associated with discharge duration of 30 minutes and system sizes of 5 MW to 30 MW

Behind-the-Meter Price Trends in Q4 2017: Residential Low End Drops 5%, Non-Residential Flat

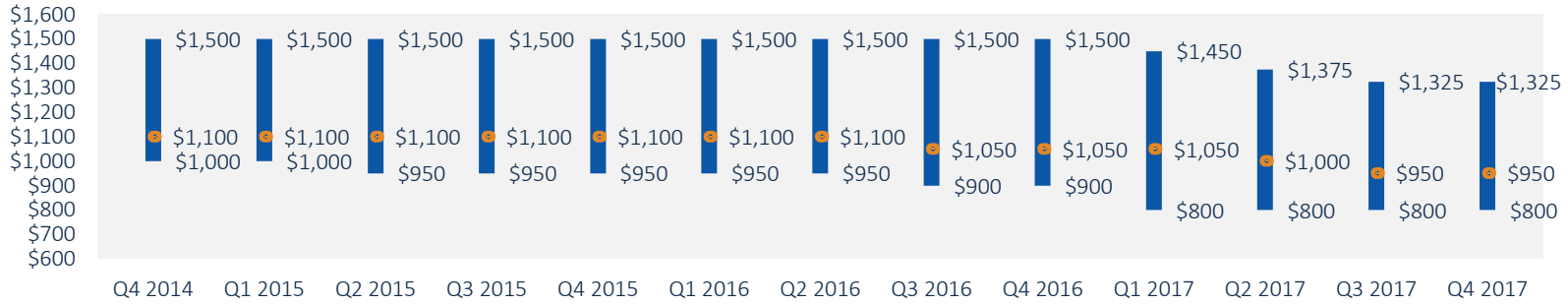
Behind-the-Meter Price Trends, Q4 2017 ($/kWh)

Source: GTM Research

- Residential system prices have remained mostly flat in Q4 2017, though the low end declined 5% from last quarter as more aggressive system pricing has begun by certain market players. Non-residential system prices remained flat quarter-over-quarter. Furthermore, declining project costs for behind-the-meter storage are evident in California's Self-Generation Incentive Program (SGIP) within Steps 1 and 2 of the 2017 program versus projects submitted in 2016, bringing SGIP system prices closer in line with what GTM Research observes in the market today. As higher volumes of behind-the-meter storage are deployed, more significant price reductions are expected.
- The non-residential segment includes a wide range of system sizes, from 10 to 20 kW up to the low-megawatt class. As a result, the low end of the range is indicative of larger systems, while the higher end of the range more accurately represents smaller systems.
- Significant volumes of behind-the-meter storage were procured in 2016 for programs like the Local Capacity Requirements (LCR), Demand Response Auction Mechanism (DRAM) and Preferred Resources Pilot (PRP) in California, and the Brooklyn-Queens Demand Management (BQDM) program in New York. Though some of these projects will not be deployed for several years, storage vied with other resources for selection within these programs, indicating increasing price-competitiveness for behind-the-meter energy storage. GTM Research expects further price declines in 2018, with non-residential median declining toward today's low end.
- All quoted prices are for systems using lithium-ion batteries with 2-hour discharge durations and without any special interconnection requirements. Residential prices are higher than system prices quoted publicly by several markets players; this disconnect stems from the fact that GTM Research's reported prices reflect fully installed systems including the cost of installation, interconnection applications and metering, while in contrast, system vendors often quote prices for systems sold to installers.

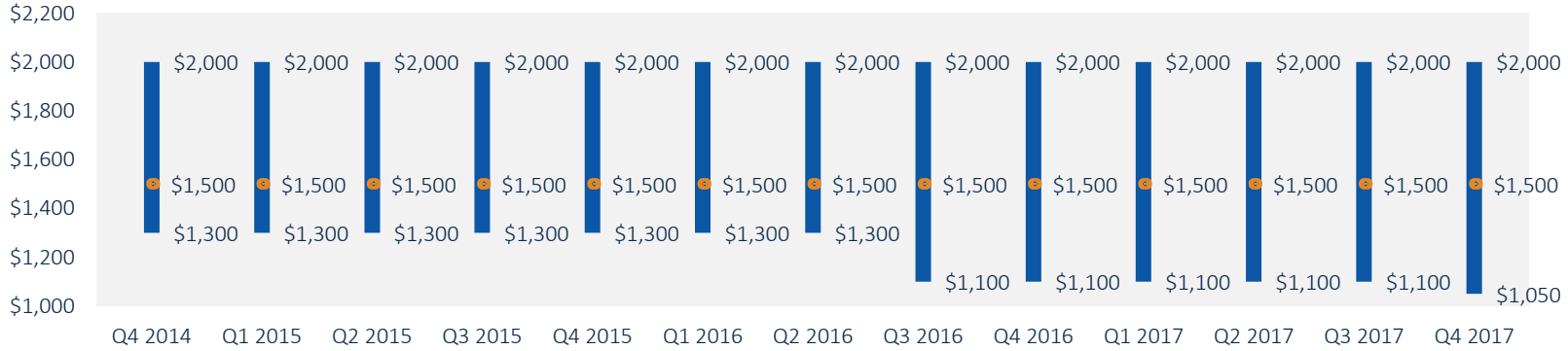
Historical System Price Trends: Behind-the-Meter Non-Residential Continues Downward Slide

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



Source: GTM Research

Historical System Price Trends: Residential ($/kWh)

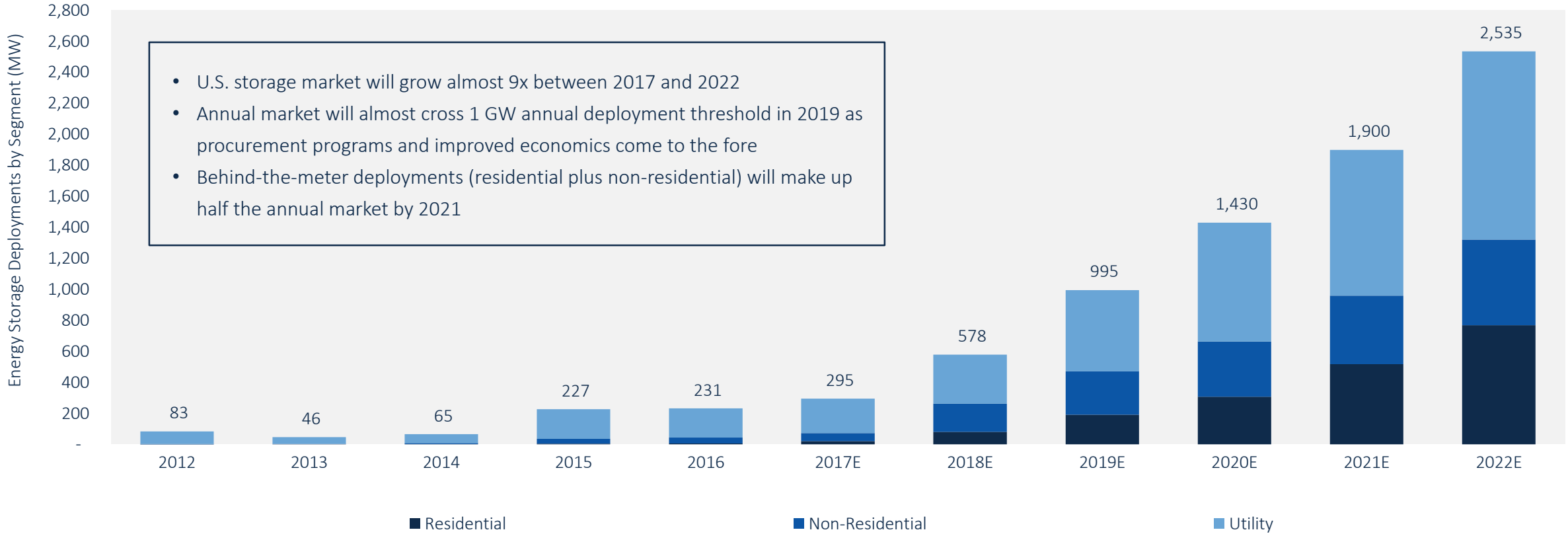


Source: GTM Research

- Non-residential system prices held flat through most of 2015, but in mid- 2016 began to experience downward pressure following a combination of increased deployment volumes and manufacturing scale-ups. Q3 2017 low prices are 11% below Q3 2016 low prices, while median prices fell 10% during the same period. GTM Research expects further price declines in 2018, as non-residential players scale up deployments and begin to deliver on contracts from the past few years.
- Residential system prices held flat from Q4 2014 through Q2 2016. However, in 2016, tech innovation and greater deployment volumes began to drive down low prices (down 15% in mid-2016). However, high and median prices remained flat, as the market still remains in an early-adopter phase, and competition between market players, while heating up, has yet to significantly push down prices. A 5% decline occurred in Q4 2017, as certain market players have begun to offer more competitive prices.

U.S. Energy Storage Annual Deployments Will Reach 2.5 GW by 2022

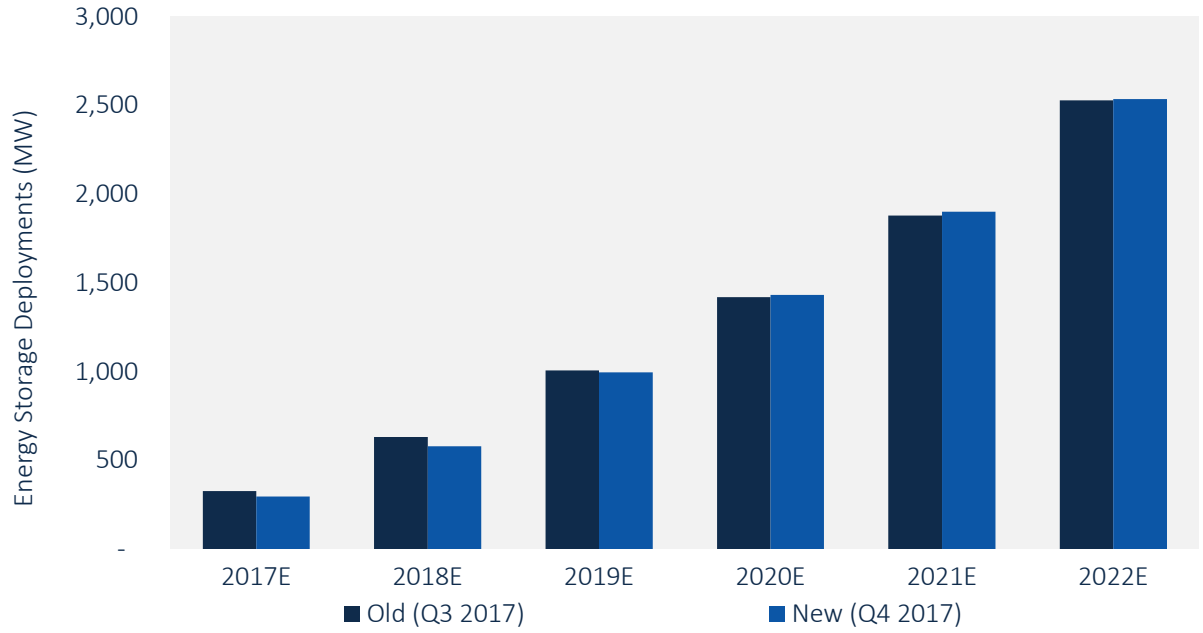
U.S. Annual Energy Storage Deployment Forecast, 2012-2022E (MW)



Source: GTM Research

2017-2022 Cumulative Energy Storage Outlook Lowered by 1 Percent

Changes to U.S. Annual Energy Storage Deployment Forecast, 2017E-2022E (MW)



Our 2017-2022 cumulative outlook shrank by 56 MW, dropping by 1% versus our previous outlook. The biggest change is in the current calendar year, 2017, for which GTM Research has lowered the expectation in a few geographies, namely, California, New Jersey and PJM territory.

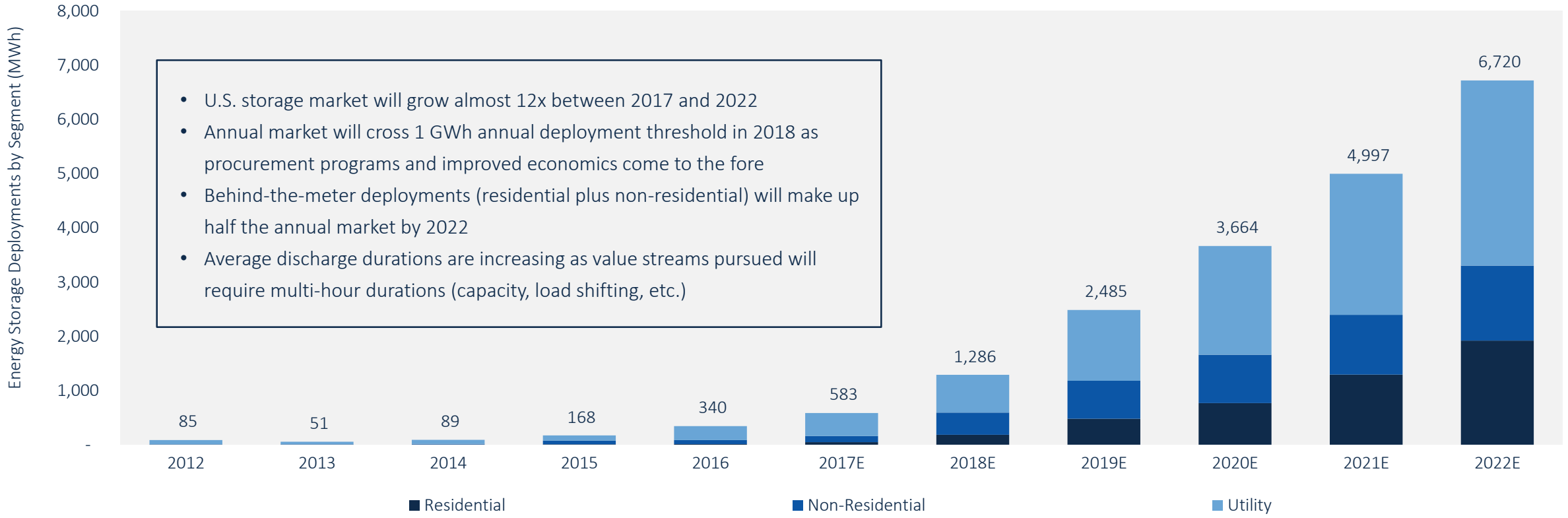
The biggest changes to the outlook are for the utility-scale segment for 2017-2022, where GTM Research lowered the outlook by 104 MW. This masks some near-term reductions in the behind-the-meter segment (2017-2018) where several markets, such as New Jersey, are expected to be softer than previously believed owing to weaker economics and the end of a specific incentive program. In contrast, the Massachusetts market is expected to be stronger than initially thought, owing to programs like SMART that will boost solar-plus-storage in the state, which led to an increased forecast.

Source: GTM Research

	2017E	2018E	2019E	2020E	2021E	2022E
Old (Q3 2017)	327	631	1,007	1,419	1,878	2,528
New (Q4 2017)	295	578	995	1,430	1,900	2,535

The U.S. Market Will Grow to 6.7 GWh by 2022

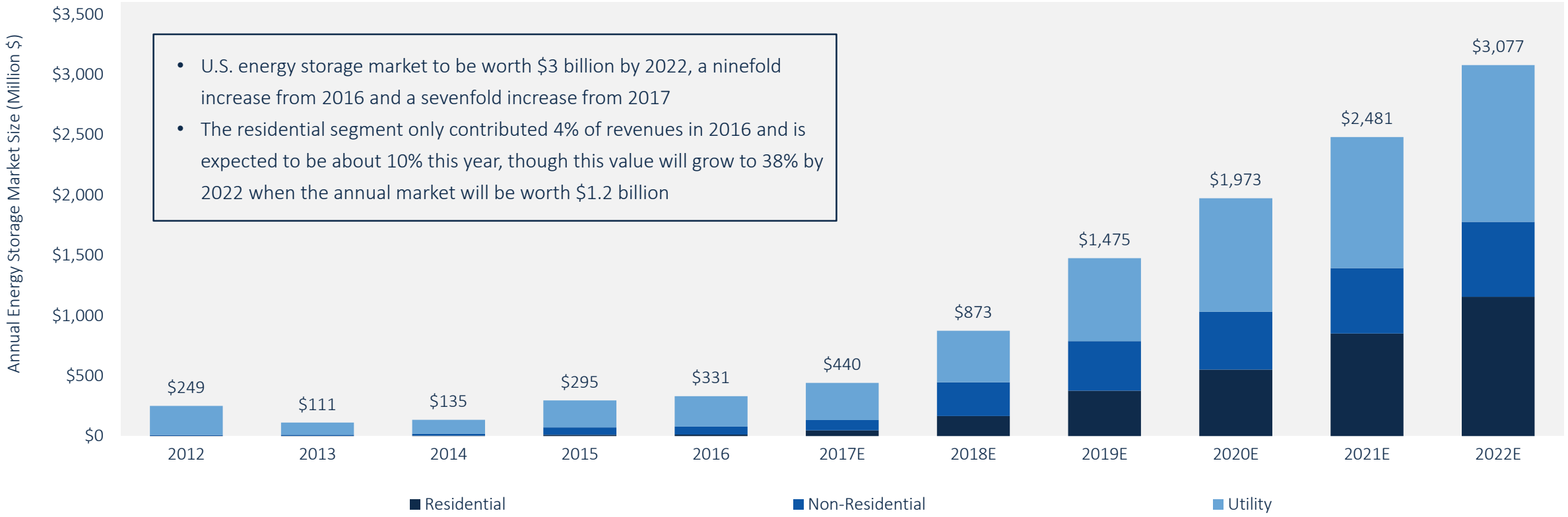
U.S. Annual Energy Storage Deployment Forecast, 2012-2022E (MWh)



Source: GTM Research

Energy Storage Will Be a $3.1 Billion Market by 2022

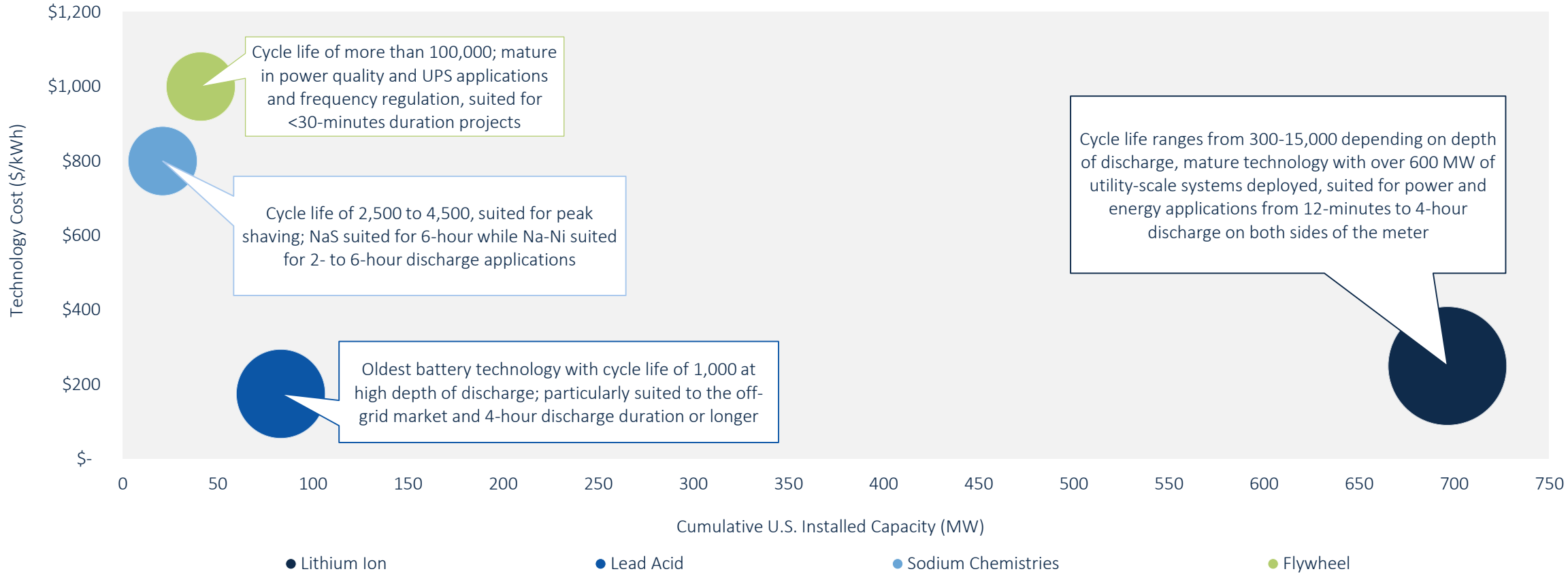
U.S. Annual Energy Storage Market Size, 2012-2022E (Million $)



Source: GTM Research

Storage Technology Comparison

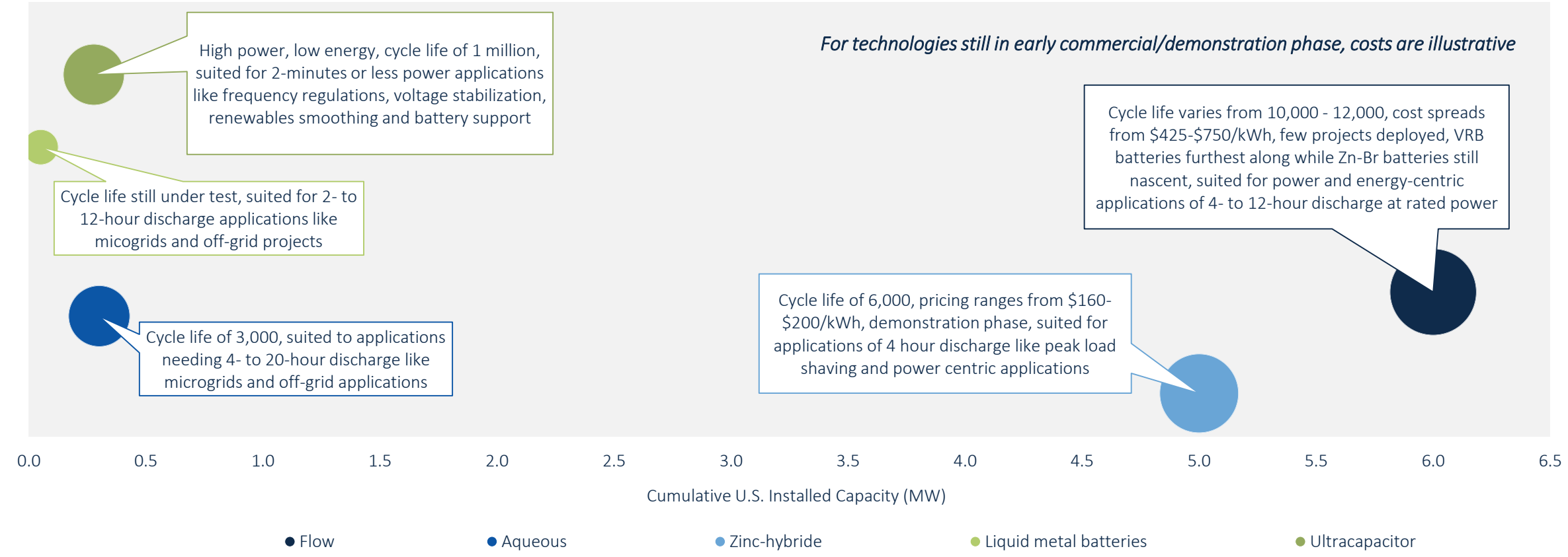
Commercialized Energy Storage Technologies: Cost ($/kWh) Versus Cumulative U.S. Installed Capacity (MW)



Source: GTM Research

Storage Technology Comparison (Cont.)

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



Source: GTM Research

Vendor Ecosystem: New Product/Service Announcements

Storage Tech Vendor	Power Electronics Vendor	Software Vendor	System Integrator	Developer	EPC/Installer	Description
	SUNGROW		SUNGROW			Sungrow unveiled its latest 250 kW, 2-4 hour duration C&I turnkey solution in September 2017 and announced its PowCube 4.8 residential energy storage system in October 2017.
			DELTA			In September 2017, Delta announced its three-phase energy storage system for C&I and utility market segment, and a residential all-in-one solar energy storage solution that features its E7U hybrid inverter.
			JLM ENERGY			JLM Energy debuted its Simple Quoting and Design tool, or SQUAD, in September 2017. SQUAD helps solar dealers to provide quotes for solar and for JLM's storage product Phazr.
Panasonic	Pika ENERGY					In September 2017, Panasonic and Pika Energy announced two configurations of their Harbor Smart Battery: Harbor Plus with 15.9 kWh and Harbor Flex with 10.6 kWh of energy capacity.

Vendor Ecosystem: New Product/Service Announcements

Storage Tech Vendor	Power Electronics Vendor	Software Vendor	System Integrator	Developer	EPC/Installer	Description
	KEHUA TECH					Kehua Tech unveiled its residential energy storage converter system specifically for the U.S. market at SPI in September 2017.
			TABUCHI ELECTRIC			In October 2017, Tabuchi Electric announced the launch of its next-generation Eco-Intelligent Battery System (EIBS) solar-storage system that is now UL 9540 certification compliant.
			electriQ			In October 2017, ElectrIQ Power's all-in-one home energy management and storage system received UL and CSA certifications. The system includes solar substring optimizers, 8-kW split phase residential or 11.4-kW 3-phase commercial hybrid solar inverter and stackable 10 kWh energy storage modules.

Vendor Ecosystem: Partnerships and M&A Activity

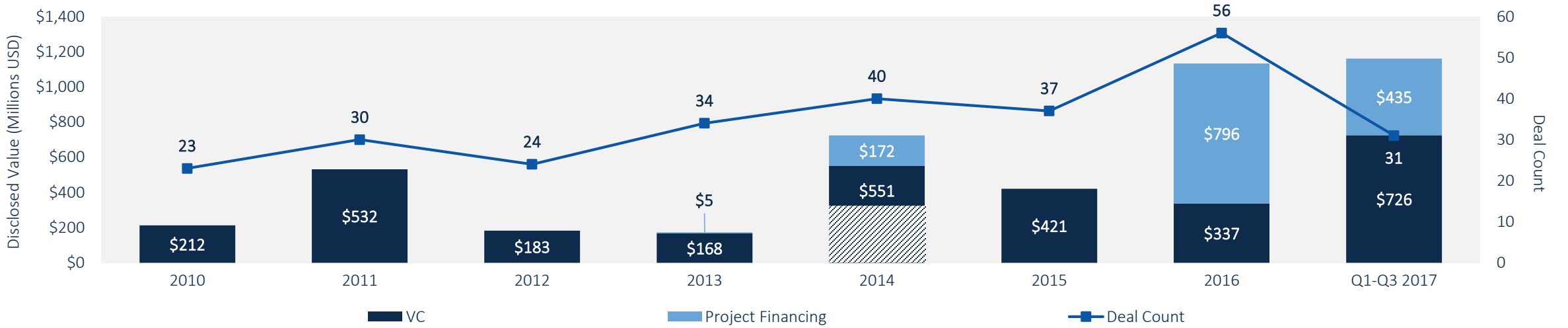
Storage Tech Vendor	Power Electronics Vendor	Software Vendor	System Integrator	Financier	Developer	EPC/Installer	Description
ALEVO							Alevo Manufacturing Inc. and Alevo USA Inc., both subsidiaries of The Alevo Group, filed for Chapter 11 bankruptcy in August 2017.
			sonnen			RGS ENERGY	In August 2017, sonnen and RGS Energy announced a partnership offering RGS Energy's residential customers with battery storage options.
PRIMUS POWER		OSIsoft.					Primus Power and OSIsoft announced a partnership in September 2017 to integrate OSIsoft's services with Primus Power's EnergyPod 2.
						NORWEGIAN SOLAR AS For a brighter future	In September 2017, PBES Norway and Norwegian Solar AS announced a partnership wherein PBES will supply containerized storage solutions for Norwegian Solar's PV systems under deployment in the U.S. and Saudi Arabia.

Vendor Ecosystem: Partnerships and M&A Activity (Cont.)

Storage Tech Vendor	Power Electronics Vendor	Software Vendor	System Integrator	Financier	Developer	EPC/Installer	Description
CALMAC						MandalayHomes	In October 2017, sonnen announced that it will partner with homebuilder Mandalay Homes to provide storage batteries to 3,000 new homes in Arizona.
			sonnen			TRANE	In November 2017, Calmac Corp, an ice-storage manufacturer, was acquired by Trane, a subsidiary of Ingersoll Rand.
		Trimark ASSOCIATES, INC.	NEC NEC Energy Solutions, Inc.				NEC Energy Solutions announced a partnership with Trimark Associates in November 2017. Trimark will deliver advanced power management solutions for NEC's distributed storage solutions.

Corporate Investments in Energy Storage Reached $110M in Q3 2017

Disclosed Corporate Investments in Energy Storage, 2010-Q3 2017 (Million $, Number of Deals)



Source: GTM Research

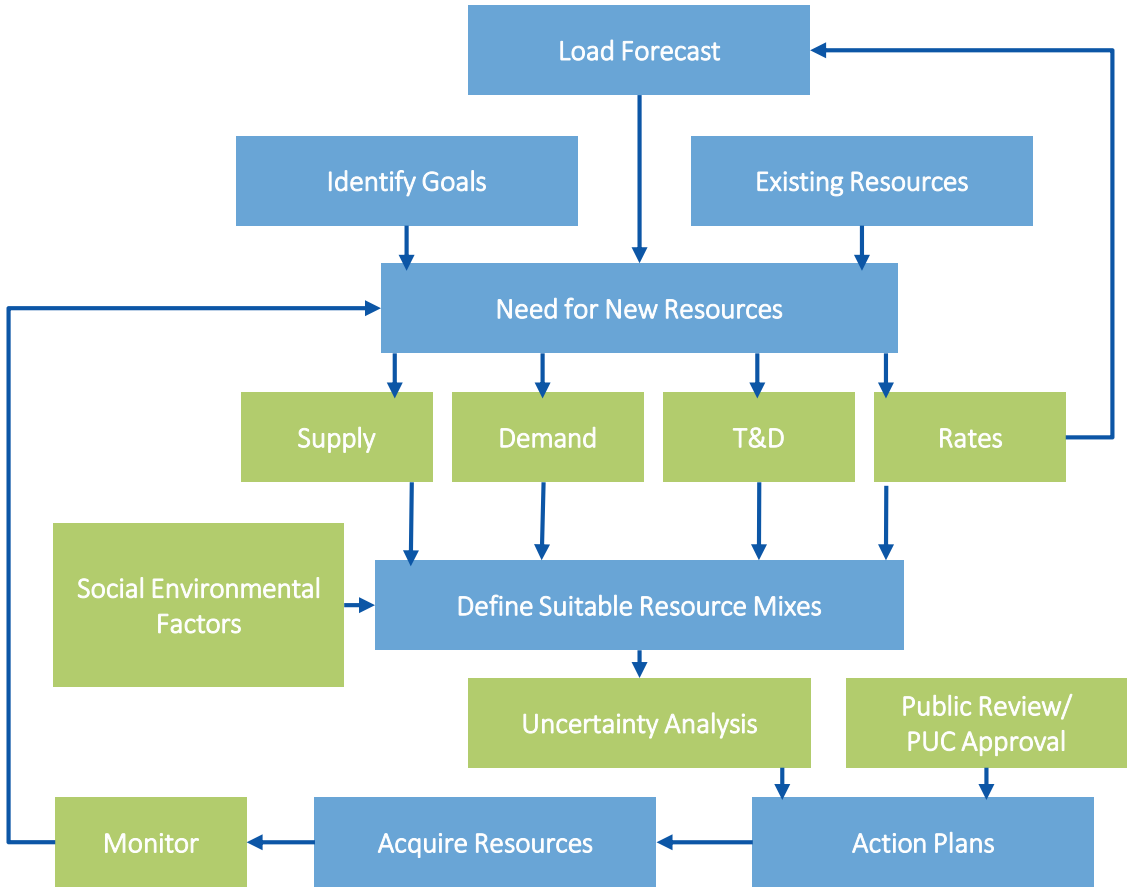
Note: The total disclosed investment in 2014 was boosted by a rumored $250 million investment in Boston-Power (shaded in the figure above); Data excludes battery materials and upstream companies. 2014 data differs from *U.S. Energy Storage Monitor 2014 Year in Review* due to exclusion of EV startup Atieva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

- Total corporate investments, including venture funding and project finance, amounted to $110.3M in Q3 2017, roughly one-sixth of the corporate investments in Q3 2016 ($664.9M)
- The largest deal announced in Q3 2017 was a $34.7M investment in Advanced Microgrid Solutions by DBL Investors, Energy Impact Partners, Macquarie Capital, GE Ventures, AGL Energy, Arnold Schwarzenegger and Southern Company. The second largest was a $30M investment in Romeo Power from undisclosed investors.
- The largest project financing in Q3 2017 was $25M received by JLM Energy arranged by GoldenSet Capital Partners, which served as a subadvisor to the North Sky Alliance Fund II.
- No M&A activity occurred in Q3 2017, though in October 2017 Enel announced the acquisition of EV charging specialist eMotorWerks, adding to Enel's overall DER strategy which includes a storage arm via Demand Energy, acquired in January 2017. Additionally, Trane announced the acquisition of thermal storage vendor Calmac in November 2017.

3. Energy Storage in Integrated Resource Plans

Utilities Are Adapting Traditional Methods of Resource Planning to Include Storage

Flow Chart for Integrated Resource Planning



Integrated resource planning (IRP) is a long-range planning process used by utilities to make decisions on supply and demand resources to meet forecasted peak load needs. Traditionally, utilities have relied on procurement of centralized generation resources to meet demand. But with the advent of energy efficiency and renewable resources in the past couple of decades, the suite of tools available to utilities has generally expanded to include demand-side management. Energy storage, particularly battery and thermal storage, was not yet on the radar for many utilities during their last set of IRP cycles, which ended as recently as 2015.

Some public utilities commissions have been progressive (often backed by clean energy advocates) in their directives to utilities to incorporate emerging technologies such as storage to provide system flexibility and improve resiliency and reliability attributes. In this section, GTM Research tracks the evolving trend of incorporating energy storage in resource planning, as well as changes in treatment of storage.

Source: Integrated Resource Planning for State Utility Regulators. Available at: http://www.raponline.org/document/download/id/817

Washington State Utilities and Transportation Commission's Policy Statement on Energy Storage

The Washington Utilities and Transportation Commission (UTC) finalized its policy statement on the treatment of energy storage in integrated resource planning and resource acquisition by the three investor-owned utilities in the state of Washington (Avista, PacifiCorp and Puget Sound Energy).

UTC's staff identified three key challenges for the fair treatment of storage:

- Lack of an organized market and hence a lack of price signals for storage service (Washington is a regulated state)
- Lack of transparency for utilities to monetize benefits and recover costs
- Modeling practices that do not identify and quantify benefits, without which storage will always be cost-prohibitive (identified as the most significant challenge)

Additionally, the UTC recognized that storage benefits need to be evaluated at both system and distribution levels. The UTC policy statement has three key components, shown below.

Changing Planning Paradigms	Modeling Guidelines	Regulatory Treatment
• Break generation, transmission and distribution silos • Include non-wires alternatives • Adapt utility business models to consider storage as investment opportunity	• Apply "net cost" approach to modeling • Short term: Use external models to incorporate sub-hourly storage benefits • Longer term: Build sub-hourly flexibility in IRP modeling	• Follow modeling guidelines, procure prudently • Factor in hard-to-quantify benefits such as resilience and reliability • Consider and apply the same principles to behind-the-meter resources

Source: https://www.utc.wa.gov/docs/Pages/DocketLookup.aspx?FilingID=161024

All Washington IOUs Have Storage Built In to Their Resource Planning

Avista: In its 2017 IRP, Avista modeled storage distribution deferral value at three feeder locations, as well as storage value to the bulk power system in the form of arbitrage, load following, reserves and regulation. Arbitrage and load following would provide for a combined 92% of all system benefits. Avista's preferred resource strategy includes 5 MW/15 MWh of storage added in 2028, and also considers additional storage in alternative scenarios, with as much as 215 MW/645 MWh storage in its new thermal resources scenario.

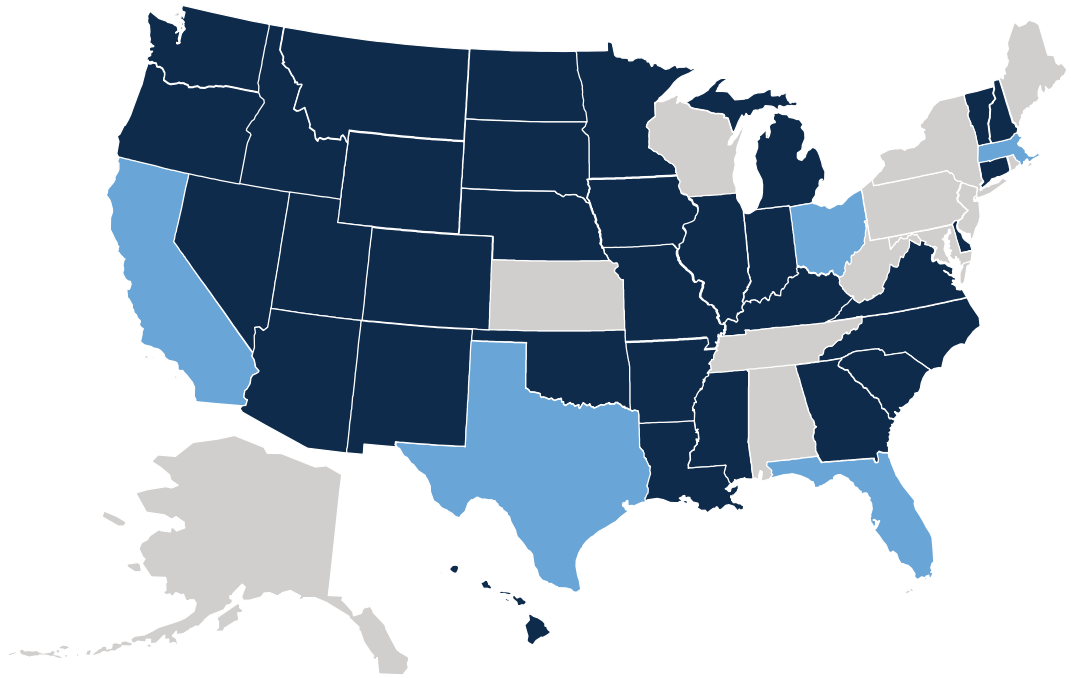
Puget Sound Energy: In a 2017 draft IRP, PSE concluded that batteries are "cost-effective primarily because they can be sized to fit needs with slowly growing loads, in addition to being very flexible." Every PSE scenario has at least 50 MW of energy storage, and a few even have 100+ MW. PSE concludes that additional demand response and energy storage is a longer-term risk mitigation strategy. Like Avista, PSE has also provisions for storage procurement as non-wires alternative in distribution system planning.

PacifiCorp: In its 2017 draft IRP, PacifiCorp has modeled two specific storage scenarios of 80 MW battery storage and 80 MW compressed air energy storage in 2021 across its California, Oregon and Washington footprint. PacifiCorp's preferred strategy, however, does not include any incremental energy storage.

Source: IRP documents from Avista Utilities, Puget Sound Energy and PacifiCorp

Storage Is Emerging as a Tool in IRPs Across Multiple Utilities

States With Integrated Resource Planning or Similar Requirements

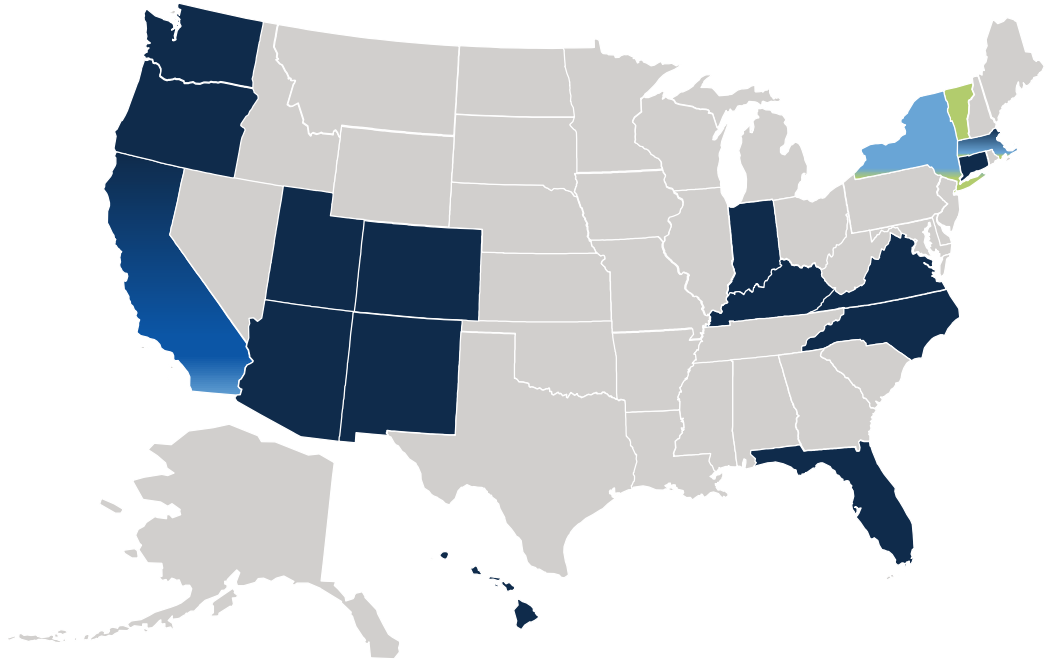


States With IRP Requirement

States With Long-Term Plan Requirements

Source: EPA Energy and Environment Guide to Action – 2015, GTM Research

States With Utilities Including Storage in Resource Planning or Rate Cases



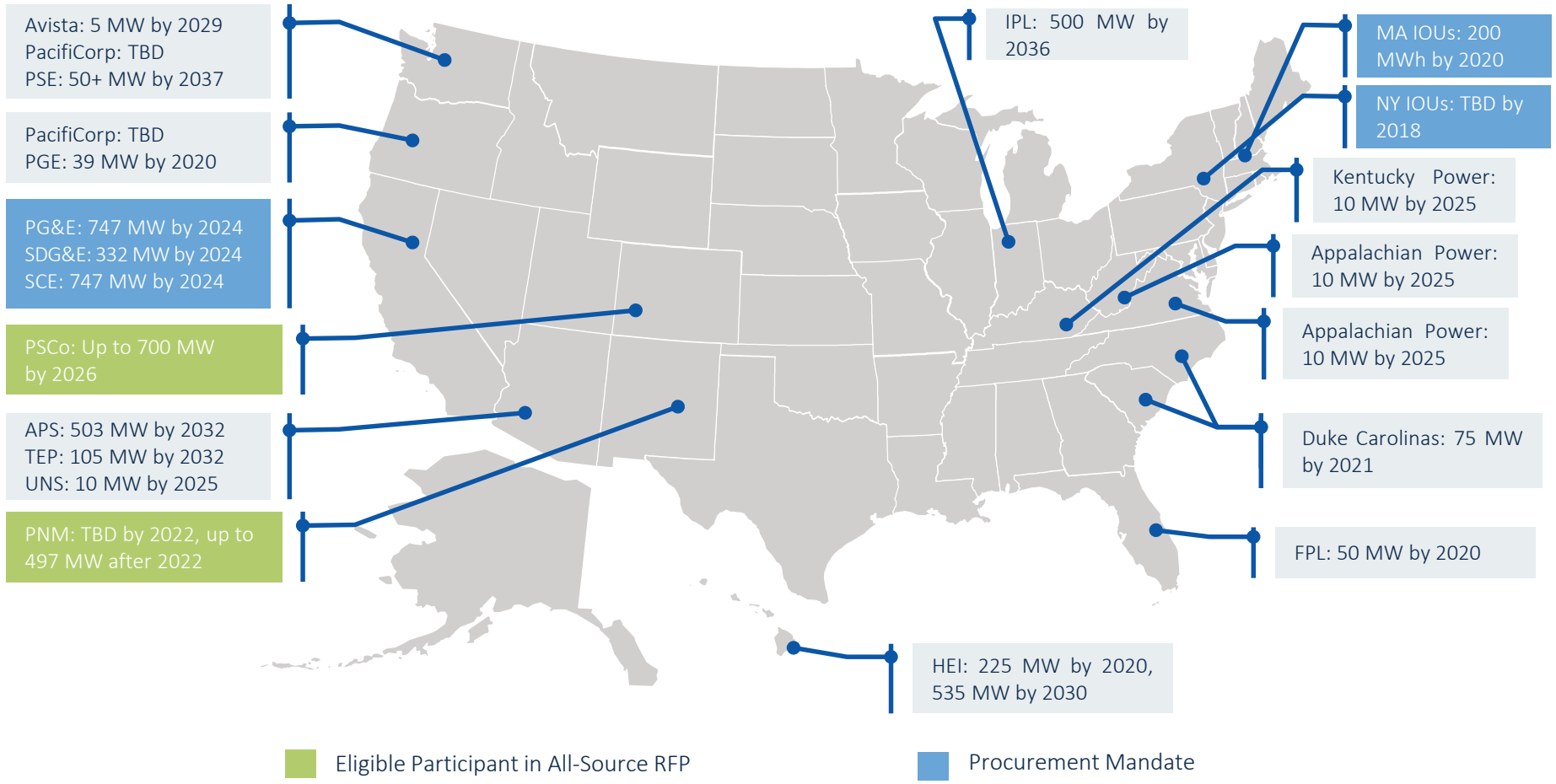
Storage in IRP/LTPP

Procurement Mandate

Distribution Planning/State Energy Plan

Source: GTM Research

Almost 2 GW of Storage Modeled in Utilities' IRPs; More Storage Eligible in RFPs and Mandates



Source: GTM Research

Challenges to Storage Treatment in Long-Term Resource Planning

While several utilities are considering storage in their long-term resource planning, many of them are still wrestling with the appropriate treatment of storage. This is evidenced by some quotes found in reviewed IRPs:

- Avista, 2017: “Energy storage costs are significantly lower than the last IRP, which for the first time makes the technology operationally attractive in meeting energy needs in the 20-year timeframe of the 2017 IRP.”
- Dominion, 2017: “To the extent that DER proliferation and the adoption of EVs and battery storage continues, the Company must be prepared to meet a new paradigm.”
- IPL, 2016: “By comparison, the 2014 IRP analysis indicated less than 50 percent of the wind resources selected in this IRP, no solar additions and did not even include energy storage as a selectable option.”

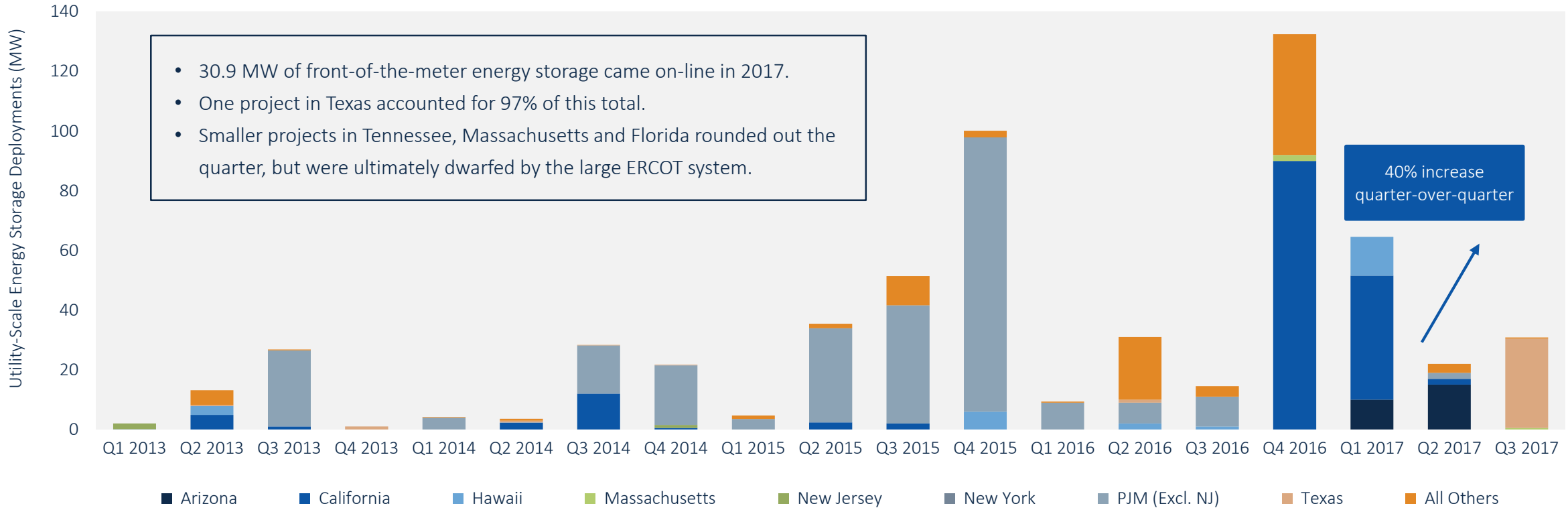
In order to incorporate energy storage in a future-proof way in resource planning, some elements that merit consideration are:

- Up-to-date cost inputs
- Downward sloping cost curve for future cost projections
- Sub-hourly modeling where possible
- Net cost of capacity (for multiple-use assets, using capacity when idle)
- Pertinent reliability metrics (i.e., flexibility, not just peak)
- Risk management metrics in scenarios

4. Utility-Scale Market Trends

Texas Leads a Spike in Megawatts Deployed in Q3 2017

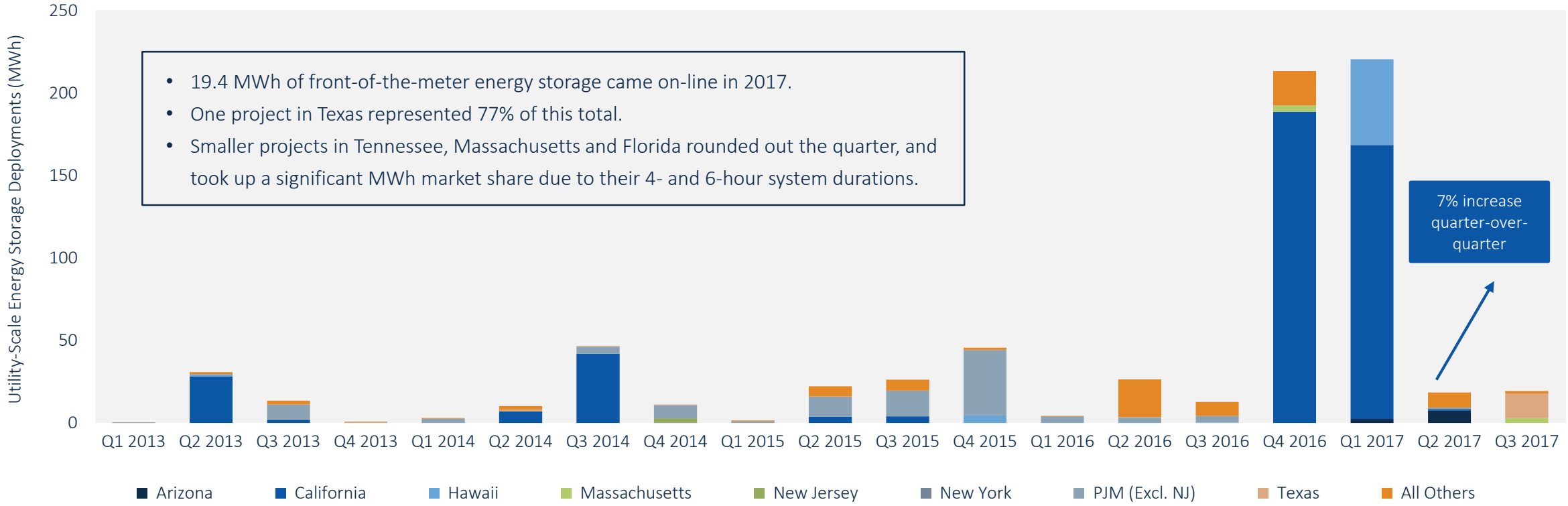
U.S. Quarterly Utility-Scale Energy Storage Deployments (MW)



Source: GTM Research

Smaller 4- and 6-Hour Systems Cut Into Texas' Q3 2017 MWh Market Share

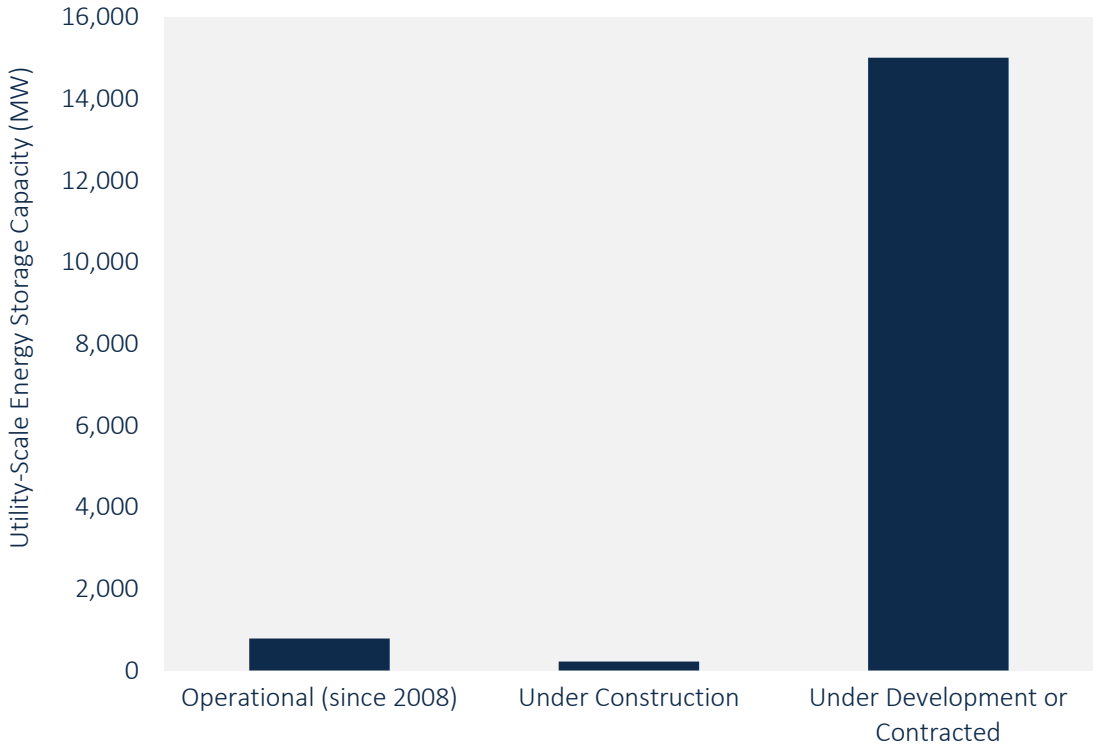
U.S. Quarterly Utility-Scale Energy Storage Deployments (MWh)



Source: GTM Research

U.S. Utility Energy Storage Pipeline Grows as CAISO Interconnection Applications Spike

U.S. Utility-Scale Energy Storage Deployment and Pipeline (MW)



Source: GTM Research

- The total utility-scale pipeline through Q3 2017 is 15,230 MW, of which 219 MW are under construction, while 15,012 MW are under development.
- Note that as of Q4 2016, GTM Research no longer includes the wholesale distribution access tariff queues for California's investor-owned utilities, as there is a significant overlap with the California ISO interconnection queue.
- 92 MW of the 209 MW under construction are in PJM territory. PJM also has 200 MW of pipeline under development, down from 349 MW a few quarters ago, as unfavorable frequency regulation signal changes have suppressed development. It remains unclear how much of this pipeline will ultimately be commissioned, as developers examine the effects of new regulation signal rules on project viability.
- The pipeline held relatively steady over the previous quarter, with some new projects proposed in California and other markets canceling out the minor drops from PJM's pipeline.
- Several of the projects listed as battery systems in CAISO's interconnection queue are enormous, well beyond the scope of any project installed to date, and even potentially beyond the capability of the supply chain to support, indicating that they may be speculative and not representative of long-term planning.

U.S. Utility Energy Storage Pipeline Still Concentrated in a Few Markets

U.S. Utility-Scale Energy Storage Deployment and Pipeline Through Q3 2017 (MW)

Market	Operational (Since Q3 2008)	Under Construction	Under Development or Contracted
Arizona	25.5	0.025	2,666
California	166	100	10,517
Hawaii	53.3	2.0	146
Massachusetts	3.0	0.5	3.0
New Jersey	2.8	0.5	20.4
New York	20	0.2	259
PJM (Excl. NJ)	306	92.4	201
Texas	77.3	19.8	664
All Others	126	3.0	535
Total	**780**	**219**	**15,012**

Source: GTM Research

- The front-of-the-meter pipeline increased in Q3 2017 to 15,012 MW (up from 14,698 MW in Q2 2017), with the majority of newly identified pipeline projects focused on the California market.
- Arizona's pipeline increased dramatically in Q2 2017 due to several of the largest projects in the latest CAISO cluster application being located in the Arizona portion of CAISO's footprint. This pipeline is made up of some projects so large they strain credulity, and so Arizona's stated pipeline should be taken with a grain of salt.
- Arizona's ascension to No. 2 drops Texas to the third-largest pipeline, though two compressed-air projects make up the majority of this total.
- GTM Research includes Hawaiian Electric's 60 to 200 MW RFP at 90 MW, as reported in the utility's Power Supply Improvement Plan submitted to the Hawaii PUC.

U.S. Utility Energy Storage Pipeline by Requested Commissioning Date (MW)

Projected U.S. Utility-Scale Energy Storage Pipeline by Requested Commissioning Date (MW)

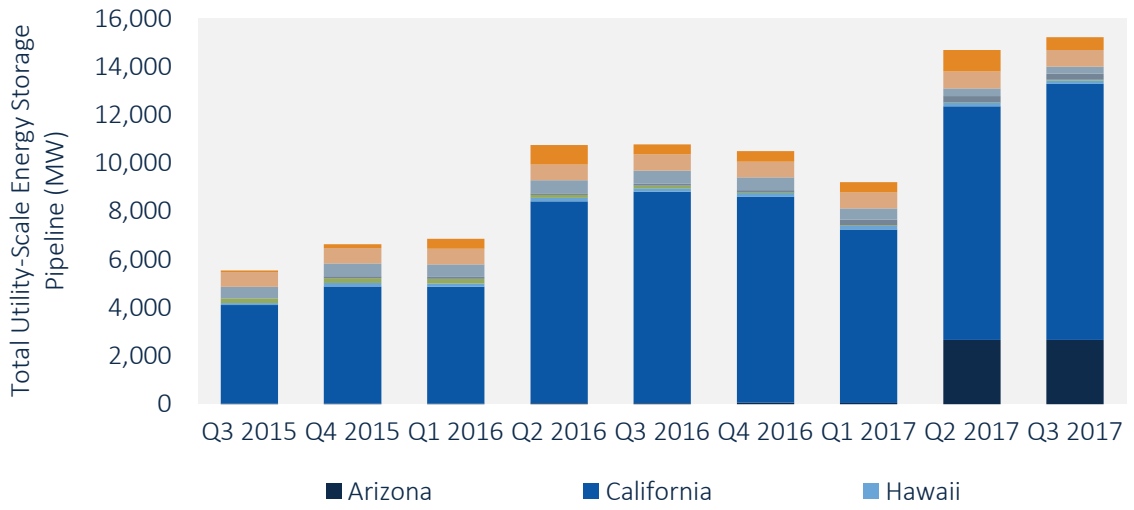
Market	2017	2018	2019	2020	2021	2022+	Unspecified/Delayed
Arizona	10	2	30	2,083	0	530	12
California	8	543	2,478	4,210	2,650	719	10
Hawaii	0	20	90	0	0	0	38
Massachusetts	0	3	0	0	0	0	1
New Jersey	20	0	1	0	0	0	0
New York	24	50	175	0	0	0	10
PJM (Excl. NJ)	49	112	0	0	0	0	132
Texas	30	270	0	374	0	0	10
All Others	206	45	154	50	0	0	82
Total	**347**	**1,045**	**2,928**	**6,716**	**2,650**	**1,249**	**294**

Source: GTM Research

- 347 MW of projects submitted 2017 as their requested interconnection date, but GTM Research expects that only a portion of these megawatts will actually get interconnected in 2017. Developers with projects in the PJM queue, especially in the early stages of development, will likely adopt a conservative approach to the evolving PJM market rules. New rules implemented in that market make participation by energy storage uneconomical. We are beginning to see this as the 2018 pipeline in PJM drops to 112 MW, with many projects past their stated commissioning target; the future of projects in the pipeline remains unclear.
- California ISO Cluster applications submitted in April 2017 included large blocks with 2019 and 2020 as the requested interconnection period. It is unlikely that all projects will get interconnected, given the timeline of AB 2514 and the fact that several of those projects did not win any RFPs. Of particular note is the size of several projects listed as solar-plus-storage projects with incredibly large (GW-scale in the case of one project listed for Arizona) storage portions, which are unlikely to move forward at that scale.
- The Texas pipeline consists primarily of two compressed-air projects with interconnection targets of 2018 and 2020, totaling 594 MW.
- It should be noted that the project pipelines in all other markets are potentially under-reported, as projects on the distribution grid or in regulated markets do not apply to ISOs/RTOs for interconnection queue requests.

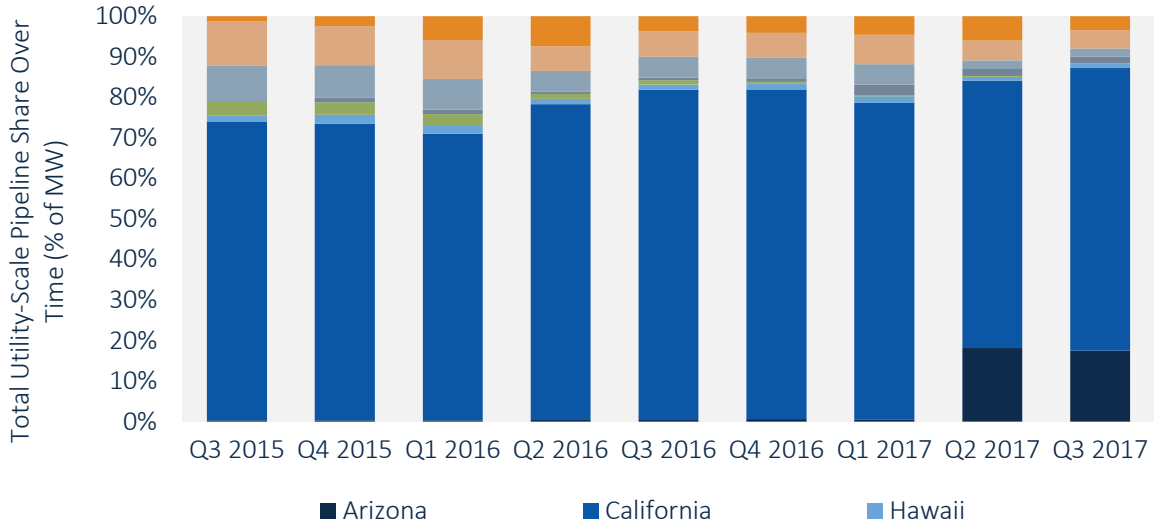
California Pipeline Grows; Other ISOs See Their Interconnection Queues Shrink

U.S. Utility-Scale Energy Storage Pipeline by Market, Q3 2015-Q3 2017 (MW)



Source: GTM Research

U.S. Utility-Scale Energy Storage Pipeline Market Share, Q3 2015-Q3 2017 (%)



Source: GTM Research

- California continues to represent the majority of the utility-scale energy storage pipeline, holding 70% of the pipeline, up from 66% of the total pipeline in Q2 2017.
- California added several significant projects added to the CAISO interconnection queue, which continues to be the primary driver for raw pipeline MW capacity.
- The "other markets" category saw its share of the pipeline drop to 3.5% from 6%, as several projects fell off of the ISO-NE and MISO interconnection queues. A full list of tracked projects and interconnection queue applications is available in GTM Research's Energy Storage Data Hub.

Front-of-the-Meter Policy and Market Developments, Q4 2017

Washington

The **Utilities and Transportation Commission** instructed all investor-owned utilities to consider energy storage in all future integrated resource plans.

Oregon

Portland General Electric announced plans to install $50 million-$100 million worth of energy storage totalling ~39 MW, the high limit of the Oregon energy storage mandate.

California

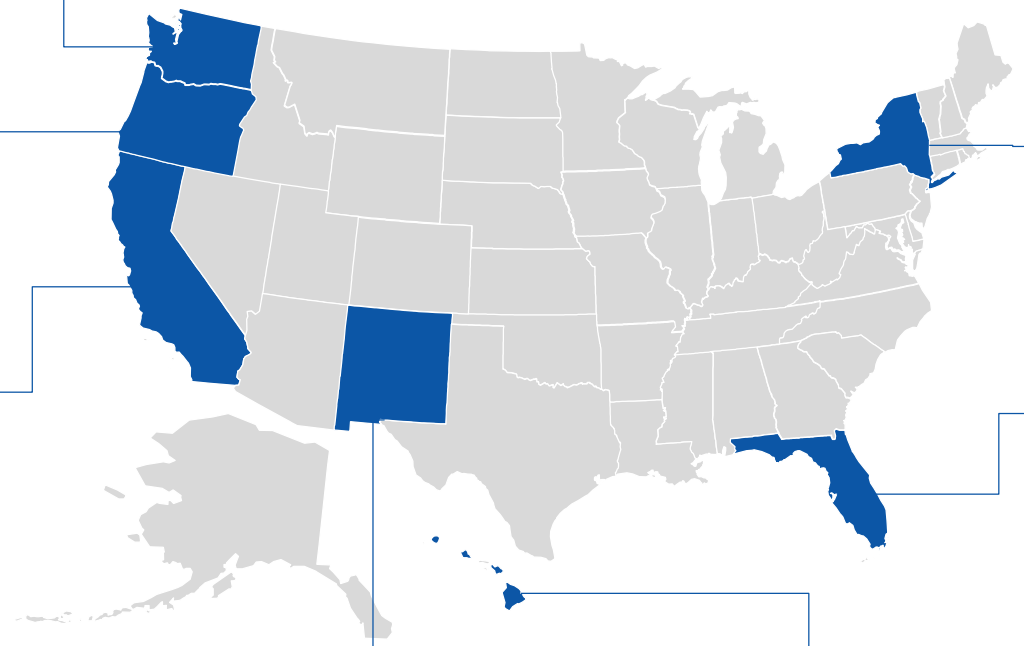
The **state legislature** passed SB 338, requiring load-serving entities to consider energy storage in integrated resource plans. **CAISO**'s ESDER Phase 3 proposes creating a load-shifting product.

New Mexico

The **Public Service Company of New Mexico** put out an RFP in October seeking alternatives to the soon-to-be-closed coal-fired units at the San Juan generating station, specifically encouraging renewable and energy storage projects to bid.

ISO / RTO Markets

Activity continues in proceedings in **PJM** and **MISO**, while energy storage was dealt a setback in **ERCOT** as stakeholders rejected a proposal to create a frequency response product.



Federal

Four bills were introduced in the **U.S. Senate** in the fall of 2017 that could advance energy storage, including another attempt to secure a tax credit for energy storage and multiple efforts to increase resiliency after the intense 2017 hurricane season.

New York

NYISO released the final draft of its Distributed Energy Resource Pilot Program Guide.

Florida

Duke's revised settlement includes plans to install up to 50 MW of energy storage in Florida as part of a pilot program alongside additional EV infrastructure.

Hawaii

HECO released its updated grid modernization plan, which highlighted energy storage throughout, including significant discussion of customer-sited storage.

California Talks Load-Shifting, Combating the Duck Curve

California Governor signs SB 338: Energy storage could be a key tool in taming the "duck curve"

- Abundant solar energy has caused the California "duck curve" – the load profile featuring huge ramp rates to peak evening demand after solar output declines – to grow faster than many analysts had expected. While numerous solutions have been proposed to address the issue, SB 338 approaches the issue of peak demand from a legislative angle by directing load-serving entities to consider non-natural-gas resources in their integrated resource planning process when considering energy and reliability needs during peak demand hours.
- The text of the bill specifically names energy storage alongside existing renewable energy, energy efficiency, and distributed energy resources as resources utilities should consider when planning around peak demand.
- While the bill comes short of the earlier proposed "clean peak standard" (AB 1405), it is the latest movement by California's legislature toward decarbonization, and yet another example where the rulemaking bodies have pointed directly to storage as an opportunity to address the region's electricity supply challenges.
- Providing a cheaper alternative to natural-gas peaker plants has long been seen as a potential future business model for energy storage, and a study from the University of Minnesota's Energy Transition Lab has recently lent credence to the opportunity by finding that storage plus solar could compete with natural gas when factoring in declining costs and state policies. In California the Puente natural-gas power plant has been suspended as stakeholders look toward alternatives, including storage.
- The storage industry will be following the next round of California utility integrated resource plans even more closely to see how they value storage as a peak asset for long-term planning.

Load-shifting is also a key topic of inquiry in California ESDER Phase 3

- In September 2017, CAISO announced that it is considering a "load-shifting" product as part of the ESDER Phase 3 initiative. The product would differentiate from the load consumption product, which could incentivize wasteful consumption, by focusing on shifting energy to other times to ensure it is productively used. The effort is partially focused on behind-the-meter applications, with full implementation in 2019.
- Market recognition for load shifting would be a boon for energy storage, adding a clear revenue stream for storage assets.

Dinosaur No More? PGE's Storage Plan Shows a Utility Outpacing Regulators

Portland General Electric Company announced in November 2017 plans to install as much as 39 MW of energy storage, spending between $50 million and $100 million on a range of storage projects.

A megawatt-scale target proposed by a utility would be news enough, but a look at the numbers raises even more eyebrows when considering Oregon's (relatively limited) energy storage mandate. That law requires utilities to procure 5 MWh, a level which 39 MW of storage will likely exceed dramatically.

Notably, however, the mandate puts a limit of 1% of each utility's peak load, meaning utilities had to consider an upper limit when planning energy storage deployments. That total for PGE? 38.7 MW. This means that PGE is planning to procure the maximum amount of energy storage allowed under law.

Thus we have the first case of a utility hitting a regulatory *ceiling* on how much energy storage it can procure, indicating that appetite from utilities may be outpacing the ability of legislatures to recognize the demand. This is the latest signpost in the utility-driven trend GTM Research has been tracking, and it reinforces that these traditionally slow-moving entities are quick on their feet when it comes to reaping the potential benefits of energy storage.

Proposed energy storage deployments include (from PGE's filing):

- A microgrid pilot at customer and community sites. PGE will install batteries alongside existing solar and biomass facilities to improve resilience.
- A battery at a substation to provide energy and capacity and other ancillary services
- A storage asset integrated into the Baldock solar facility, which is an existing 1.75 MW solar array. This will be an opportunity to integrate large-scale solar along with automation to increase reliability.
- Up to 500 residential, behind-the-meter, PGE-controlled batteries throughout PGE's service area to pilot the development of a residential storage program and operate a distributed, aggregated fleet of storage assets
- A 4 to 6 MW transmission-connected storage device to create a "hybrid plant" at PGE's Port Westward 2 facility. The project will allow PGE to realize the full value of the spinning reserves of an offline turbine (18.9 MW), reducing fuel use and emissions at the plant or allowing another plant (i.e., hydro) to operate at full capacity.

Fall 2017 Sees a Spate of New Energy Storage Bills, but Will They Advance?

Several bills, detailed below, were introduced in the fall 2017 session of Congress that would advance or prioritize energy storage, including a new attempt to include storage in the Investment Tax Credit and a bill focusing on natural disaster resiliency. All bills are at very early stages of discussion, and their prospects in a highly partisan chamber with an already packed schedule remain uncertain.

S.1851: Advancing Grid Storage Act of 2017

- Would require the Department of Energy to create an energy storage research program, providing technical and grant assistance to programs for deploying and demonstrating energy storage technologies. The $50 million program would apply through 2022 and would prioritize grid resiliency, microgrid and islanding applications, and integration of renewable resources.

S.1868: Energy Storage Tax Incentive and Deployment Act of 2017

- Would amend IRS code on energy investment tax credits to include energy storage technologies including batteries, pumped hydro, flywheels, thermal energy storage, among others, in effect extending the 30% ITC to energy storage.

S.1875: Flexible Grid Infrastructure Act of 2017

- Would direct the Department of Energy to conduct a broad study at least once every three years that would identify emerging grid technologies, including energy storage, and quantify their potential benefits to the grid. The bill would also direct the completion of separate work creating modeling tools for distributed energy resource and energy storage deployment.

S.2041: Rebuilding Resilient Energy Systems Act of 2017

- Would direct that any repair of an energy system or building following a natural disaster consider future resiliency, reliability and public welfare, along with maximizing usage of renewable resources and energy storage.

Front-of-the-Meter Energy Storage Roundup

- In **Florida**, **Duke Energy** filed a revised settlement agreement with the Florida Public Service Commission which includes plans to install up to 50 MW of energy storage as part of a pilot program. The settlement, which also includes additional investment in solar energy, EV infrastructure, and more customer choice, was approved by the Florida PSC in October 2017.
- In August 2017 **HECO** released its updated grid modernization plan, which highlighted energy storage throughout, including significant discussion of customer-sited storage. In October 2018 the Hawaiian Electric Companies began soliciting proposals for new renewable generation with the option for developers to include energy storage in their bids.
- In October 2017, **NYISO** released the final draft of its Distributed Energy Resource (DER) Pilot Program Guide. The program would demonstrate the integration of distributed assets into the NYISO wholesale market system and inform broader market design efforts that address the challenges of integrating distributed resources.
- Utility regulators in **Washington** issued a ruling in October directing all state investor-owned utilities to consider energy storage in their integrated resource planning processes. This further accelerates the trend of utilities addressing storage in their IRPs (for a more in-depth discussion on the subject, see the In Focus section of this report).
- The **Public Service Company of New Mexico** put out an RFP in October seeking alternatives to the soon-to-be-closed coal-fired units at the San Juan generating station, and is specifically encouraging renewable and energy storage projects to bid. The total capacity to be procured is 456 MW, with proposals due in January. If energy storage systems win a fraction of the total capacity up for bid, it will be an excellent signpost that the technology is increasingly cost-competitive with other capacity or peaker resources.

Utility-Scale Market Outlook: Applications

GTM Research analysis suggests that there will be four broad application areas for utility-scale energy storage.

Ancillary services: Historically, PJM had been the only market with sufficiently high regulation prices to provide a clear entry opportunity for new merchant energy storage. Recently, however, systems have gone on-line in other regions, and a 30 MW system providing regulation in ERCOT drove the lion's share of this quarter's deployments. Even regions without frequency regulation wholesale market products are considering whether to procure energy storage for ancillary services, particularly as they deal with greater penetration of renewables. ISO-NE and MISO have recently tweaked their fast-regulation market rules, and the Southwest Power Pool is actively working to develop them. Ancillary services are seeing deployments outside of ISO footprints, in applications as varied as providing black-start services in the Imperial Irrigation District in California to managing the Arizona grid.

Capacity and demand management: SCE has led energy-storage procurement for local capacity requirements, and SDG&E has followed suit, even expediting its projects in response to the Aliso Canyon gas leak. Utilities in New York state have issued RFPs for utility-scale energy storage to meet their capacity needs. Utilities in the Northeast U.S. are increasingly looking to energy storage as a means to reduce capacity payments. Massachusetts' storage mandate is expected to result in increased storage procurement by state utilities for capacity needs, and multiple utilities across the country have included energy storage as a capacity resource in their integrated resource plans.

Generation and T&D deferral: Utilities are beginning to value electricity infrastructure-investment deferral use cases for energy storage, as evidenced by PG&E's distribution deferral RFO and the recent activity in Arizona and Massachusetts, as discussed previously in this report. However, in the restructured markets, storage used for deferral cannot be bid into wholesale markets until initiatives such as ESDER phase 2 and others become operational. This will result in storage procurements for deferral continuing to occur through bilateral agreements, such as the ones in place in Arizona, Ohio and Washington. In a policy statement, FERC supported simultaneous use of storage for market and cost-recovery applications. A newly announced 8-hour project in Nantucket, Massachusetts indicates that this could be a strong market for long-duration systems.

Renewable integration: Hawaii and Puerto Rico were some of the first markets to deploy energy storage for renewable integration. A similar trend is now being seen in California and Arizona, among other markets, where the concept of firm solar PPAs is gaining traction. SRP in Arizona is deploying a 40 MWh system, while Tucson Electric Power recently announced a 120 MWh solar-paired system scheduled to come on-line in 2019. Municipal cooperatives have made moves on solar-plus-storage projects as well; examples include Austin Energy, Connecticut Municipal Electric Energy Cooperative, Kauai Island Utility Cooperative, and most recently the Brunswick Electric Membership Corporation in North Carolina.

Utility-Scale Market Outlook: Markets

GTM Research's outlook on key utility-scale markets is presented below.

California: California will lead utility-scale energy storage deployments through 2022, with over 1.3 GW of new utility-scale storage, mainly driven by AB 2514 procurement targets.

Hawaii: HECO in its most recent Power Supply Improvement Plan reported a 70 MW project in Oahu with a 2019 completion date and an additional 100 MW for regulation. GTM Research expects deployments toward this PSIP will be responsible for most of the market growth in Hawaiian Electric Utilities' footprint, with an upside if additional ancillary services and load-shifting needs are identified, as well as with additional storage procurement by Kauai Island Utility Cooperative.

Arizona: With APS' recent Integrated Resource Plan calling for more than 500 MW of energy storage by 2032, Tucson Electric Power announcing a 120 MWh solar-paired system, and Salt River Project even getting in on the action with a 40 MWh solar-paired system, Arizona has emerged in 2017 as a key market to watch for grid-side energy storage over the next several years.

Massachusetts: Massachusetts is the third state to pass an energy storage mandate, announced to be a 200 MWh "aspirational" target by January 1, 2020. Based on the economics of these projects, the Department of Energy Resources may increase or enhance the storage target over the following years, resulting in a potential upside market through 2025.

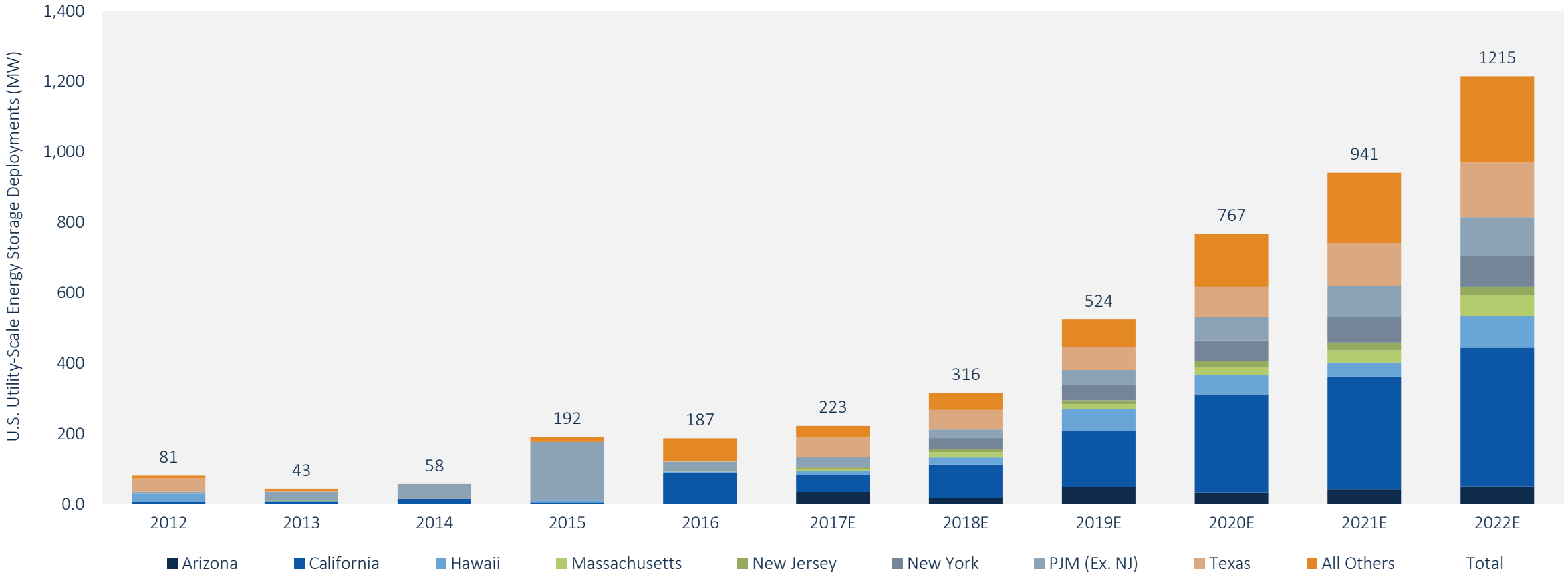
PJM: PJM will continue to grow at a slower pace (compared to the boom years of 2013 through 2015) in the short term, as changes to the dynamic regulation signal have significantly altered project economics in the ISO's territory. There will be a resurgence as PJM revamps and storage finds its footing in capacity performance products and other applications across the large market. The market's upside is significantly reliant on FERC, which may require the ISO to review its energy storage participation requirements through the complaint filed over the regulation market changes or through the notice of proposed rulemaking released in November 2016.

Texas: Despite passing on reforming its ancillary services market last year, some small projects have been installed or planned in the region. Further upside for the market relies on planned compressed-air energy storage projects, though their future and financing remains up in the air. Bethel Energy Center, the first of the two CAES projects to receive interconnection approval, could come on-line in 2020.

All Others: The Midwest, New England, Pacific Northwest states and Puerto Rico have taken the early charge on utility-scale energy storage adoption in the "All Others" market category.

Utility-Scale Market Outlook (MW)

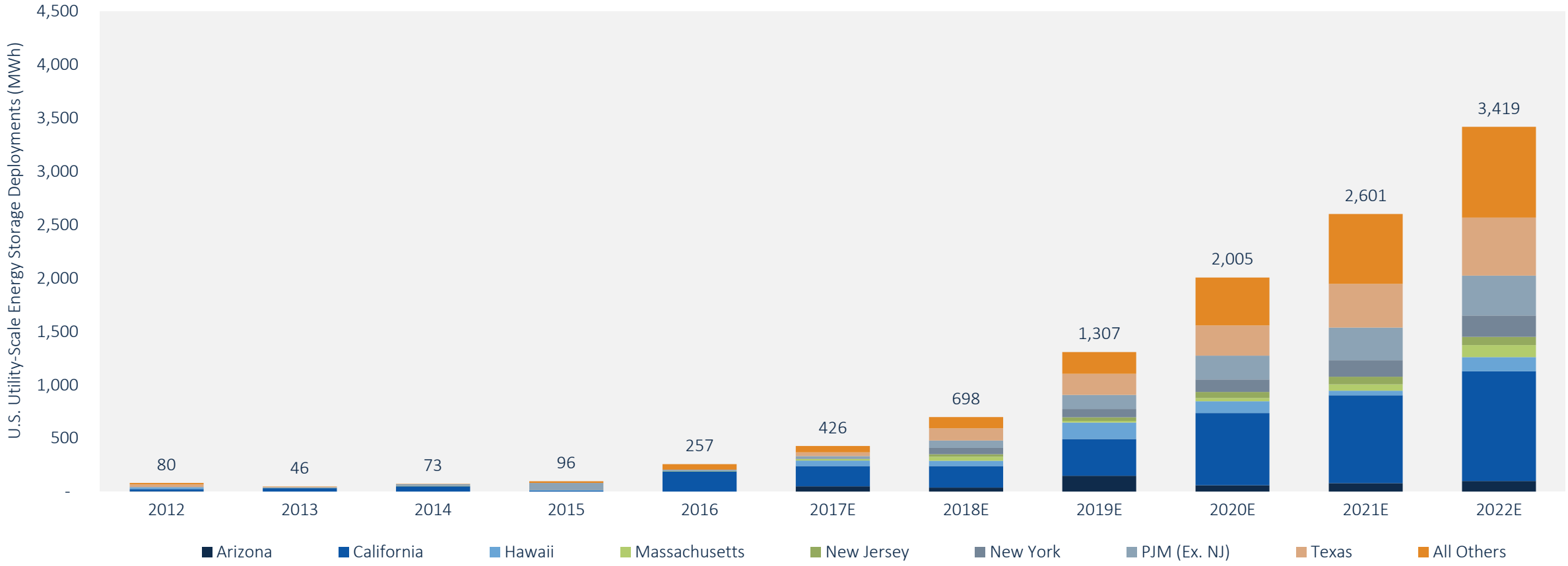
U.S. Annual Utility-Scale Energy Storage Deployment Forecast, 2012-2022E (MW)



Source: GTM Research

Utility-Scale Market Outlook (MWh)

U.S. Annual Utility-Scale Energy Storage Deployment Forecast, 2012-2022E (MWh)



Source: GTM Research

5. Behind-the-Meter Market Trends

Behind-the-Meter Policy and Market Developments, Q4 2017

Nevada

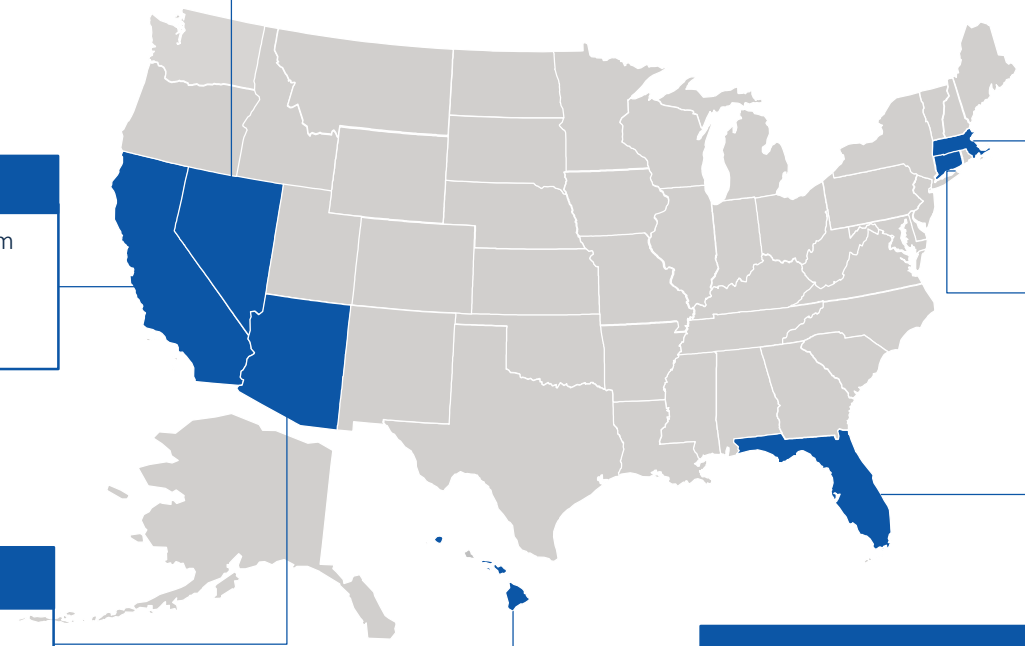
Nevada PUC approved new NEM rules.

California

CPUC approved the SGIP Equity Budget to allocate program funds for projects in low-income and disadvantaged communities. The **governor** signed AB 546 into law to streamline storage permitting.

Arizona

APS proposed a new tariff program to encourage adoption of non-residential storage to address peak demand.



Massachusetts

Mass. DPU opened an investigation on whether energy storage should be allowed to net meter and whether net-metered systems can have capacity bid into ISO-NE's FCM.

Connecticut

CT DEEP opened Round 4 of its microgrid program which includes an incentive for storage.

Florida

Utility **JEA** approved a storage incentive and a new NEM compensation structure, both of which take effect in early 2018.

Hawaii

Hawaii PUC issued new program rules for net metering: Smart Export and CGS+. **KIUC** proposed new NEM rules that resemble those used by HECO.

Equity Budget Creates $55M Carve-Out for Storage in Low-Income and Disadvantaged Communities

- In October 2017, the California Public Utilities Commission approved Decision 17-10-004 to establish an equity budget for the Self-Generation Incentive Program (SGIP). 25% of funds collected for energy storage projects through SGIP starting with Step 3 will be allocated only to projects that meet the equity budget's criteria:
  - "State and local government agencies, educational institutions, nonprofits, or small businesses are eligible for the incentives if they are located in either: census tracts determined by CalEnviroScreen to be in the 25% most affected statewide, plus those census tracts that score within the highest 5% of CalEnviroScreen's pollution burden but do not receive an overall CalEnviroScreen score," as well as low-income housing and disadvantaged communities
  - Applies to both large-scale and small residential categories
  - 10% of the equity budget reserved for single family and multi-family low-income housing regardless of the size of the energy storage project
  - Developer cap of 20% within each step of the equity budget
- If a program administrator does not confirm any equity budget reservations for three months and five or more storage projects ineligible for the equity budget confirm reservations, then a triggering event occurs which increases the incentive amount by $0.05/kWh, though the total storage incentive can never exceed $0.50/kWh.
- Given that the SGIP budget for Steps 3 through 5 is roughly $220 million, the equity budget will sit at roughly $55 million. Assuming the minimum amount is committed to residential systems (i.e., 10%), the program would expect to dedicate $5.5 million to residential projects and $49.5 million to non-residential projects. Given minimum incentive levels for each step while assuming the slow adoption case (i.e., incentive drops $0.05/kWh each step), equal budget allocation among steps and incentives taken without the ITC, the equity budget will lead to a minimum of 18.7 MWh of residential storage and 168 MWh of non-residential storage in low-income and disadvantaged communities. Given the nature of monetary awards under this budget, players will need to develop new strategies to tap into the low-income market; this presents an opportunity for niche storage players to develop a targeted strategy, as more established players are likely to remain focused on the standard SGIP budget.

Massachusetts DPU Explores NEM and FCM Opportunities for Solar-Plus-Storage

- In October 2017, the Massachusetts Department of Public Utilities opened an investigation (DPU 17-146) into the ability of solar-plus-storage systems to net meter and the ability of electric distribution companies to bid capacity from net-metered systems into the Forward Capacity Market (FCM) administered by ISO New England in order to offset NEM service costs using FCM market revenues. Initial written comments regarding the ability of solar-plus-storage system to net meter were due November 17, 2017 and reply comments are due December 8, 2017. Comments regarding net-metered facilities participating in the FCM are due February 1, 2018, with reply comments due February 22, 2018.
- The outcome of this investigation is murky at the time of writing as the comment period is still open, but the determination of whether or not solar-plus-storage systems can net meter and whether system capacity can be bid into the FCM will have implications for the growth of the Massachusetts storage market. If solar-plus-storage systems are allowed to net meter, we would expect an increase in solar-plus-storage deployments; though NEM opportunities often decrease the need for storage as the case for solar-only is superior, in this case one could expect some customers to be open to having the option to gain a credit for excess solar generation in cases where the storage system is at full charge, particularly if the main use case for said system is backup. If, however, stricter limits are placed on system configuration, the market will likely experience a more challenging road forward, as greater system configuration and interconnection complexities will stymie growth.
- The opportunity to bid capacity from net-metered facilities into the FCM is contingent on solar-plus-storage systems being allowed to net meter in the first place, and thus if eligibility is denied, this opportunity will evaporate. However, this second opportunity, if approved and if solar-plus-storage systems are included, would lead to another revenue stream for solar-plus-storage systems, improving the economic case and thus leading to greater adoption, though the level of this acceptance would depend on the potential revenues to be gained from the FCM. Given these parameters, the outcome is even less clear.

Behind-the-Meter Storage Roundup

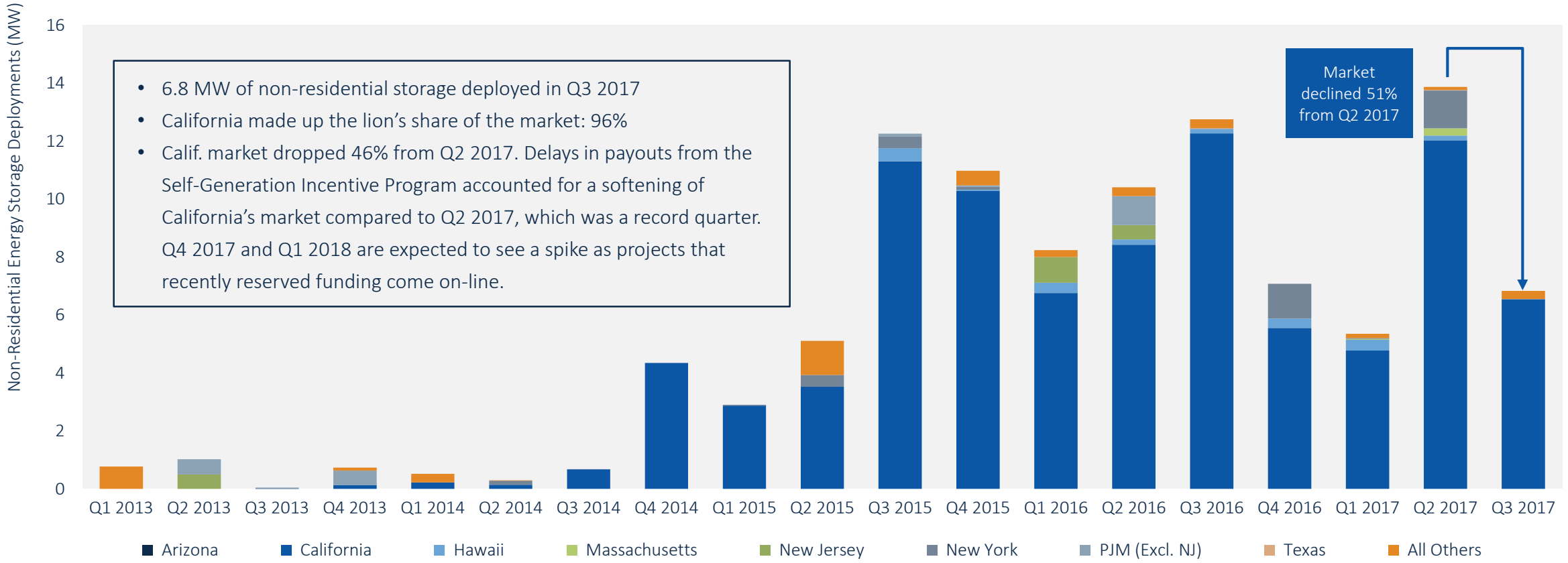
- **Arizona:** In August 2017, APS proposed an amendment to the company's non-residential rate structures which would encourage storage, known as the Large General Service Time-of-Use Storage Program Tariff. The program would have a cap of 35 MW of peak demand among participants. Enrolled customers would be required to install a storage system that could reduce peak demand by at least 20% during the on-peak period. Assuming the program is fully subscribed, a minimum of 7 MW of additional non-residential storage would result, substantial for Arizona, which historically has seen minimal non-residential storage market activity.
- **California:** In September 2017, **AB 546** was signed into law. It requires cities and counties to make all documentation and forms associated with the permitting of advanced energy storage, as defined, available on a publicly accessible website and to allow for electronic submittal of storage permit applications and associated documents. It has a deadline of September 30, 2018 for cities or counties with populations greater than 200,000 and a deadline of January 31, 2019 for cities and counties with populations below 200,000. It will lead to streamlining of the permitting process for storage and reduce overall costs currently facing developers operating across California.
- **Connecticut:** In September 2017, the fourth round of the Connecticut Department of Energy and Environmental Protection's microgrid program opened with up to **$30 million in bond funding available for microgrids at critical facilities**. While the program itself does not directly offer funds for storage, it is possible that some projects will include storage as Connecticut seeks to improve its resilience. **The program's energy storage incentive is set at $1,000/kW.** Applicants can qualify for a capital grant of up to $4M and a term loan of up to $2M, and can qualify for an additional $2M capital grant if located in a priority town and received assistance from the USDA's Rural Community Energy Assistance Program. Round 4 applications are due by January 1, 2018.

6. Non-Residential Market Trends

Behind-the-Meter Non-Residential Market

Non-Residential Market Drops to 6.8 MW as California Market Softens

U.S. Quarterly Non-Residential Energy Storage Deployments (MW)



Source: GTM Research

Non-Residential Market Drops to 14.2 MWh as California Market Softens

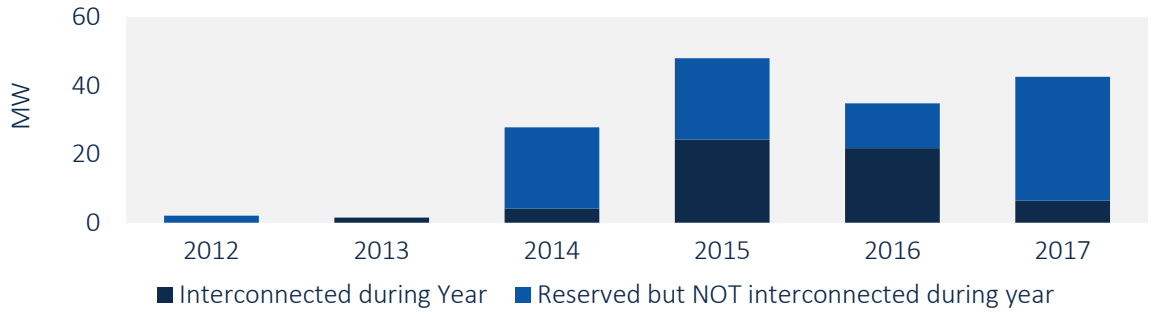
U.S. Quarterly Non-Residential Energy Storage Deployments (MWh)

Source: GTM Research

Non-Residential SGIP Reservations Surged in Q3 2017 as New Program Queue Resolves

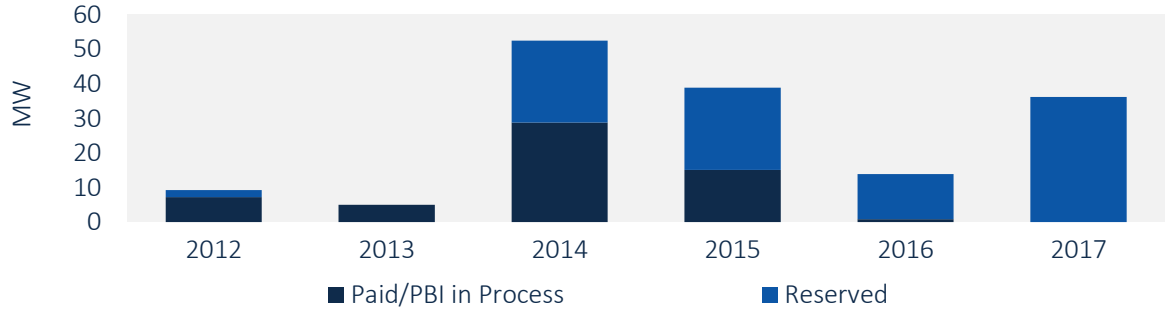
- The new iteration of the Self-Generation Incentive Program (SGIP) opened May 1, 2017. Step 1 was quickly subscribed across all four program administrators (CSE, PG&E, SCE and SCG), and as such the submitted projects entered into a lottery. Step 2 opened in early June 2017, and as of early November 2017, only SCE's allotment of large-scale storage in Step 2 had been filled. Of all projects submitted in 2017 through early November, 146 projects totaling 36.2 MW have reserved funding, a massive surge from three months ago when a mere 4.9 MW of projects had reserved funding. Step 1 of the new program offered an incentive of $0.5/Wh for standalone non-residential storage projects and $0.36/Wh for energy storage projects claiming the federal Investment Tax Credit, while Step 2 offers $0.4/Wh for standalone non-residential storage projects and $0.29/Wh for energy storage projects claiming the ITC. The incentive applies for up to 60% of eligible project costs. Note that projects under 30 kW receive an upfront incentive; projects over 30 kW receive 50% upfront and 50% via a performance-based incentive. The previous iteration of the SGIP continues to see queue-clearing activity. The final incentive level of the previous program was $1.31/W for up to 60% of eligible project costs.
- As of early November 2017, a total of 422 projects totaling 60.8 MW had received at least the 50% upfront incentive, while an additional 99 MW across 346 projects have reserved funding. A total of 59 MW of total capacity has been interconnected.
- Activity spiked in late 2017, as systems that applied for funds when Step 2 opened reserved funding. Confirmed reservation of SGIP funds took several months longer than expected given the large number of applications for the new program. Learnings from these early phases of the new program are expected to shorten the timeline for subsequent program steps.

Interconnected vs. Reserved Capacity by Year (MW)



Source: CPUC (SGIP), GTM Research

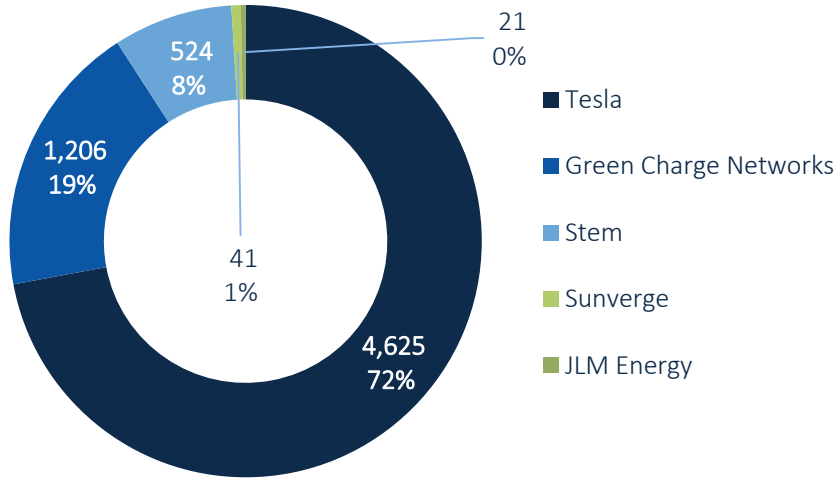
Paid vs. Reserved Capacity by Year of SGIP Application (MW)



Source: CPUC (SGIP), GTM Research

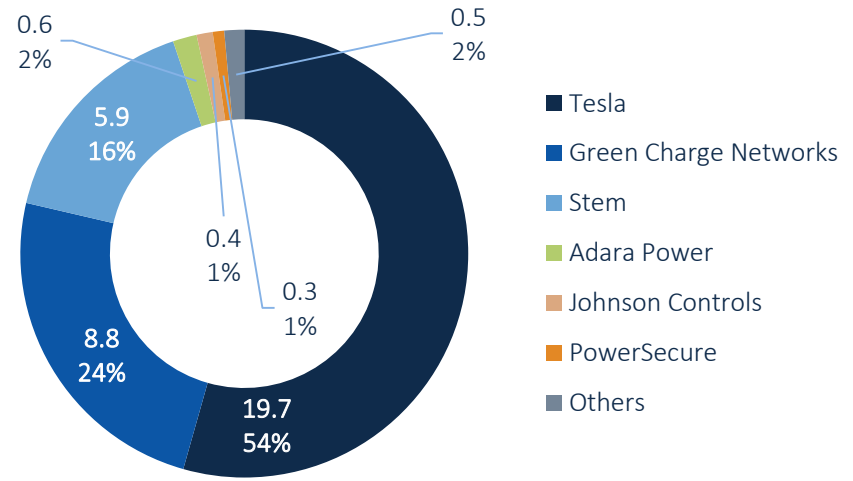
Non-Residential SGIP Reservations Surged in Q3 2017 as New Program Queue Resolves (Cont.)

Projects Interconnected in 2017, Non-Residential (kW, % Vendor Market Share)



Source: CPUC (SGIP), GTM Research

Applications Received in 2017 With Reserved Funding, Non-Residential (MW, % Vendor Market Share)



Source: CPUC (SGIP), GTM Research

- As of early November 2017, a total of 422 projects totaling 60.8 MW had received at least the 50% upfront incentive, while an additional 99 MW across 346 projects have reserved funding. Additionally, a total of 59 MW of total capacity has been interconnected.
- 6.42 MW of storage have been interconnected thus far in 2017. Tesla leads the market with 4.6 MW (72% market share), followed by Green Charge Networks with 1.2 MW (19%).
- Tesla accounts for the largest share of projects with reserved funding, with 54%, followed by Green Charge Networks with 24%. A greater diversity of players have reserved funding in recent months, including companies like Stem, Adara Power, Johnson Controls, PowerSecure, Sharp, Ice Energy and more.
- Though the new SGIP has seen rule changes, including changes to the incentive structure and a developer cap, the market is nevertheless dominated by the same vendors that held much of the market in 2016. Note that Tesla supplies batteries to a number of players while also developing projects, and thus influences the market at both ends of the value chain.

Non-Residential Market Outlook: Applications

GTM Research analysis suggests that there will be three broad application areas for non-residential energy storage: demand-charge management, resiliency and backup, and grid and wholesale market services.

Demand-charge management: A majority of commercial and industrial customers pay as much as 50% of their electricity bills in demand charges. Energy storage offers peak demand-reduction opportunities, leading to 20% to 30% electricity bill savings in many cases. Markets with high demand-charge tariffs (upward of $15/kW to $30/kW) represent a particularly attractive opportunity already, and by 2021, we anticipate even markets with tariffs of $11/kW and above will start to look attractive.

Resiliency and backup: Commercial and industrial customers can be sensitive to outages due to expensive equipment and critical facilities. States in the Northeast have established programs to increase grid resiliency, and states in the Northwest are pursuing resiliency policies, relying on energy storage along with other upgrades. However, customers with existing backup power needs may already possess this type of infrastructure in the form of diesel generators, in which case the value proposition for storage requires an additional benefit such as electricity bill reduction or reducing carbon emissions. In the wake of recent hurricanes affecting Puerto Rico, Texas and the Southeastern U.S. the resilience conversation is expected to intensify and storage will increasingly be a part of these conversations.

Grid and wholesale market services: California utilities have been at the forefront of exploring the use of energy storage for grid services, including demand response, ancillary services and local capacity. In September 2016, SCE awarded 50 megawatts' worth of contracts for demand response from non-residential energy storage and energy conservation under the utility's Preferred Resources Pilot program, while the Demand Response Auction Mechanism program recently saw at least 3.7 MW of behind-the-meter storage committed for the 2018 and 2019 delivery periods. The New York Reforming the Energy Vision initiative has entered into its demonstration phase, in which several pilot projects involve energy storage; additionally, the Brooklyn-Queens Demand Management program in New York City seeks to employ energy storage for demand response, with an expansion announced in July 2017. Hawaii recently introduced a demand response plan that proposes four grid services for which it could procure energy storage and other distributed resources. In Hawaii, HECO rolled out storage 1 MW of systems under the Energy Excelerator program to improve grid efficiency. In Massachusetts, several storage companies received funding for BTM storage projects under the MA DOER's Peak Demand Grant Reduction program, with up to 2 MWh of storage resulting in the next few years.

Non-Residential Market Outlook: Key Markets

GTM Research's outlook on key non-residential markets is presented below.

California: California will remain the strongest market for non-residential storage through 2022, though it will lose a slight amount of market share as other state markets blossom. The infusion of additional funding under the new SGIP regime will buoy the market, particularly as the new program's budget was recently doubled. Furthermore, non-residential procurements under programs like DRAM, LCR and PRP will come on-line over the next few years, adding more growth in California's non-residential storage market. California's market will see strong growth, increasing 7.5x from 33 MW in 2016 to 247 MW in 2022.

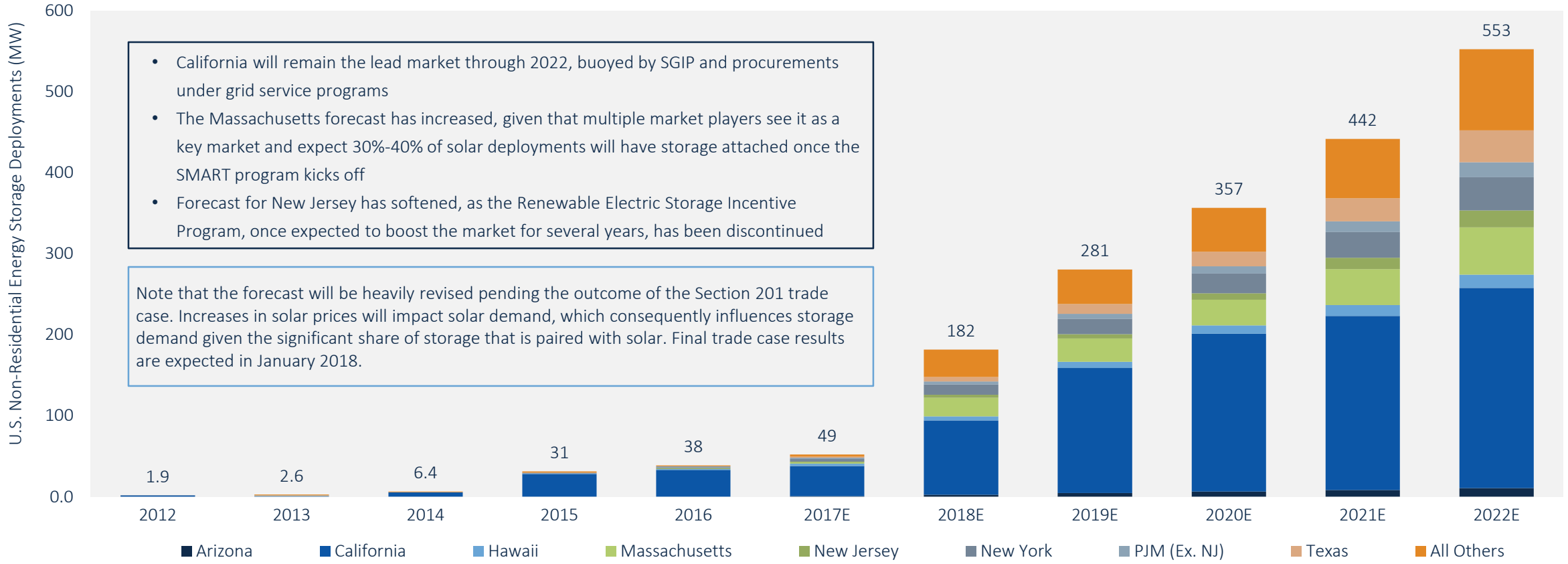
New Jersey: New Jersey's Renewable Electric Storage (RES) incentive program has been canceled and deployments to date minimal, leading to a reduction in near-term outlook for the market. Continuing drives for resilience in New Jersey will support continued growth in the storage market, with the conversation around resilience expected to increase in the wake of recent hurricanes across the U.S. The New Jersey market is expected to grow almost sixteenfold from 2016 (1.4 MW deployed) to 2022 (21 MW deployed).

New York: New York's BQDM program influenced significant procurement of non-residential storage in New York City, and these deployments will come on-line within the next few years, while further deployments are expected under the program's next stage. Furthermore, the Fire Department of New York and Department of Buildings' battery safety study is expected to help ease challenges around deploying energy storage within NYC, reducing permitting and deployment timelines. The city also has a storage target of 100 MWh by 2020, indicating greater interest in deploying the technology, particularly to deal with peak load during the summer months. Additionally, a storage mandate is currently under discussion and could lead to further market upside. New York's annual market will soar to 41 MW in 2022.

Massachusetts: Massachusetts will see a notable upside in non-residential storage over the next few years, boosted by programs such as Advancing Commonwealth Energy Storage. Furthermore, the next iteration of the state's NEM policy, known as SMART, includes an incentive for solar-plus-storage deployments, which will buoy the non-residential market. Non-residential market players indicate that Massachusetts will be a key market in 2018 and beyond, with as much as 30%-40% of the state's new solar projects to be paired with storage next year. The state's 200 MWh storage target will also likely provide some upside in the non-residential market. These factors will contribute to a 58 MW annual market by 2022.

Non-Residential Market Outlook (MW)

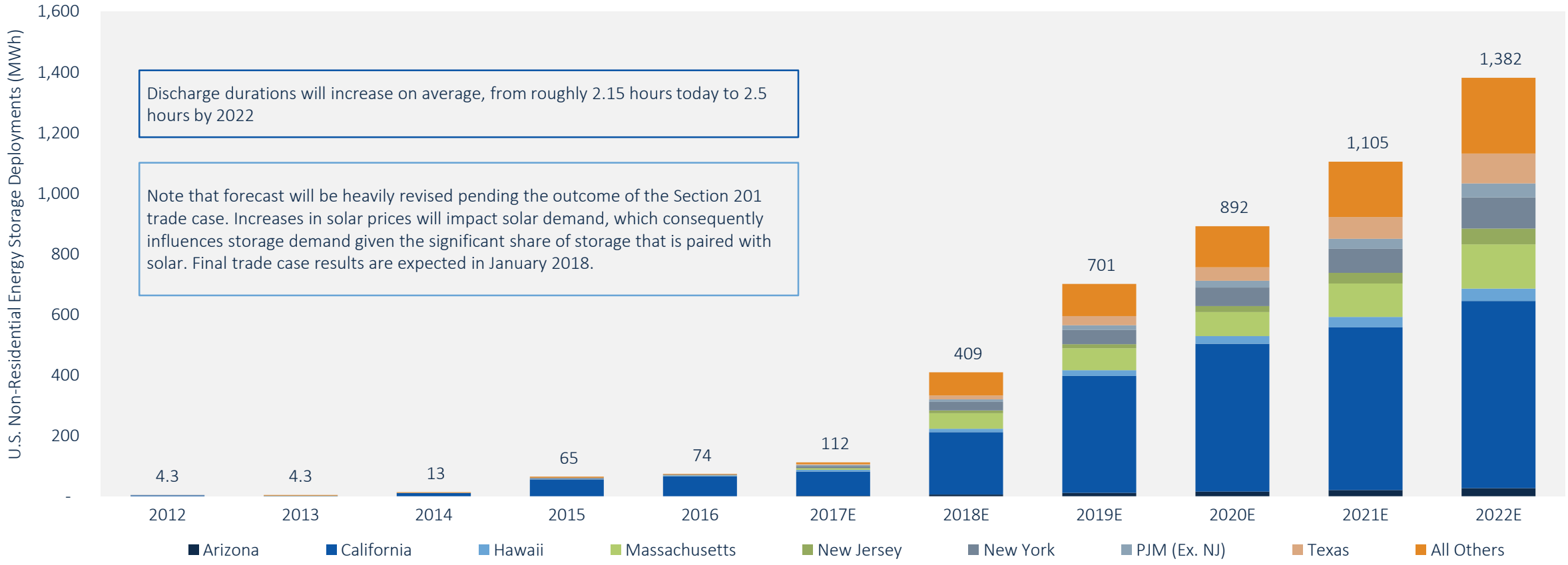
U.S. Annual Non-Residential Energy Storage Deployment Forecast, 2012-2022E (MW)



Source: GTM Research

Non-Residential Market Outlook (MWh)

U.S. Annual Non-Residential Energy Storage Deployment Forecast, 2012-2022E (MWh)



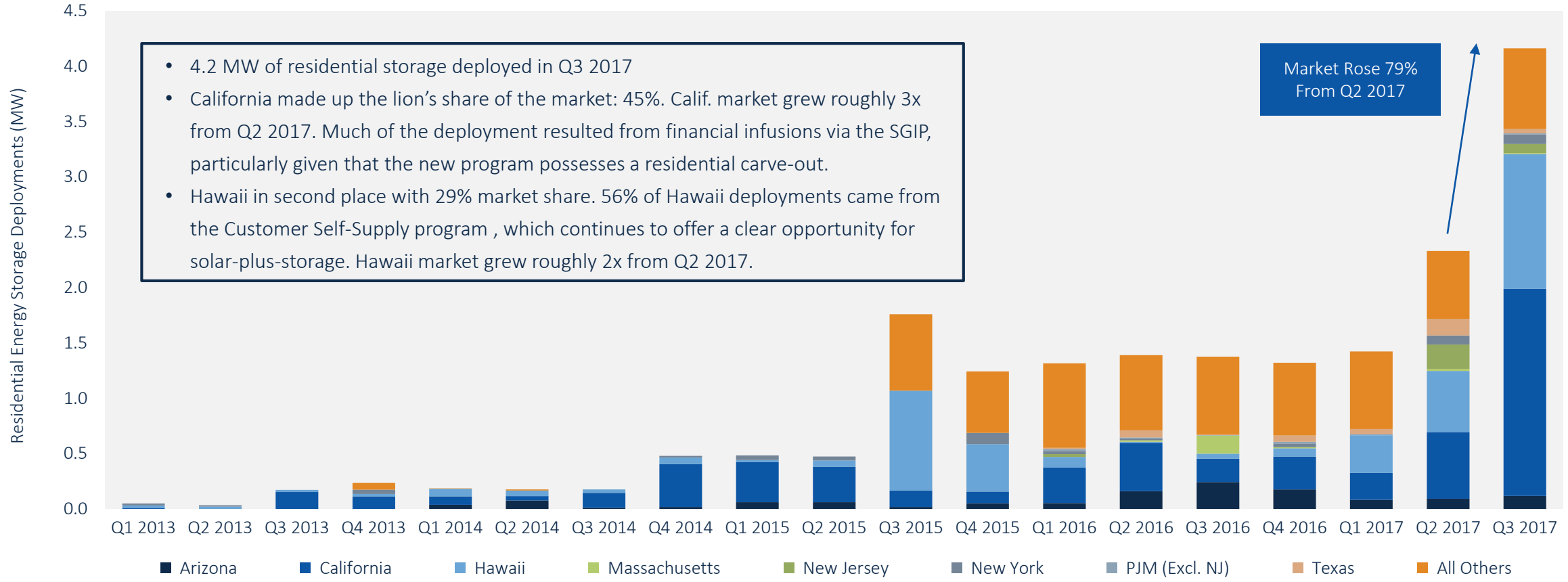
Source: GTM Research

7. Residential Market Trends

Behind-the-Meter Residential Market

Residential Market Rose to a Record 4.2 MW, Bolstered by Gains in California and Hawaii

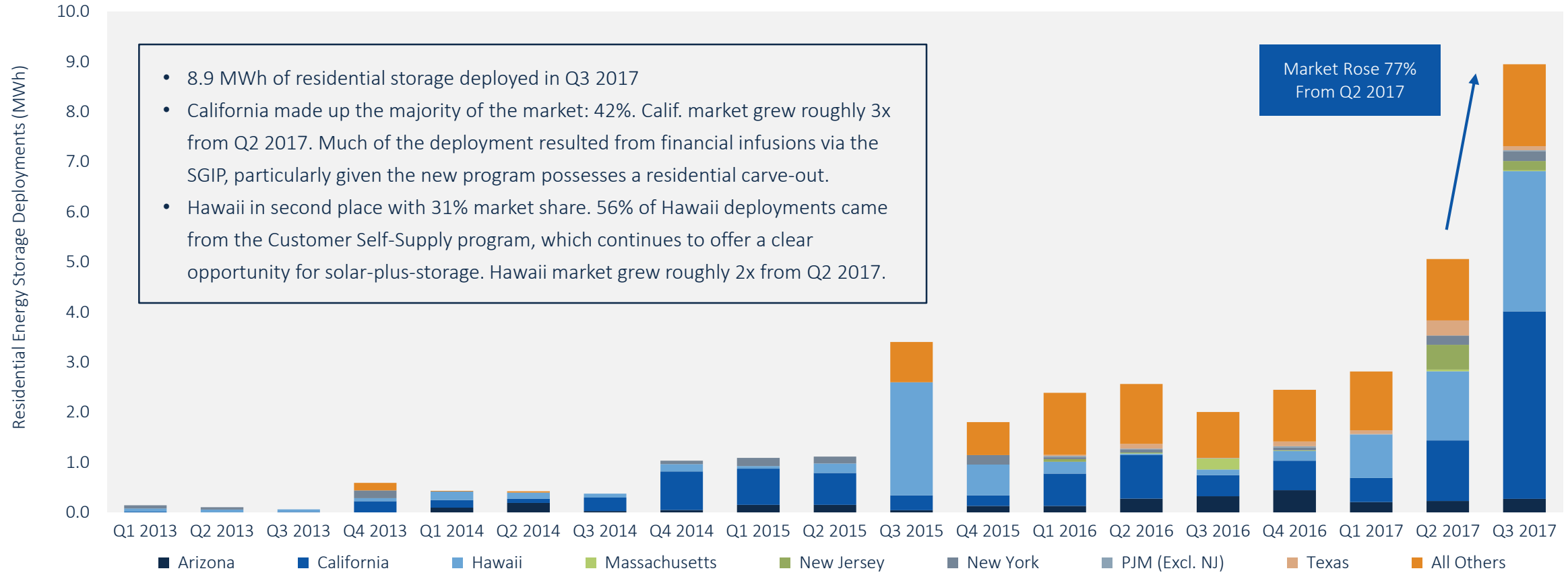
U.S. Quarterly Residential Energy Storage Deployments (MW)



Source: GTM Research

Residential Market Rose to a Record 8.9 MWh, Bolstered by Gains in California and Hawaii

U.S. Quarterly Residential Energy Storage Deployments (MWh)

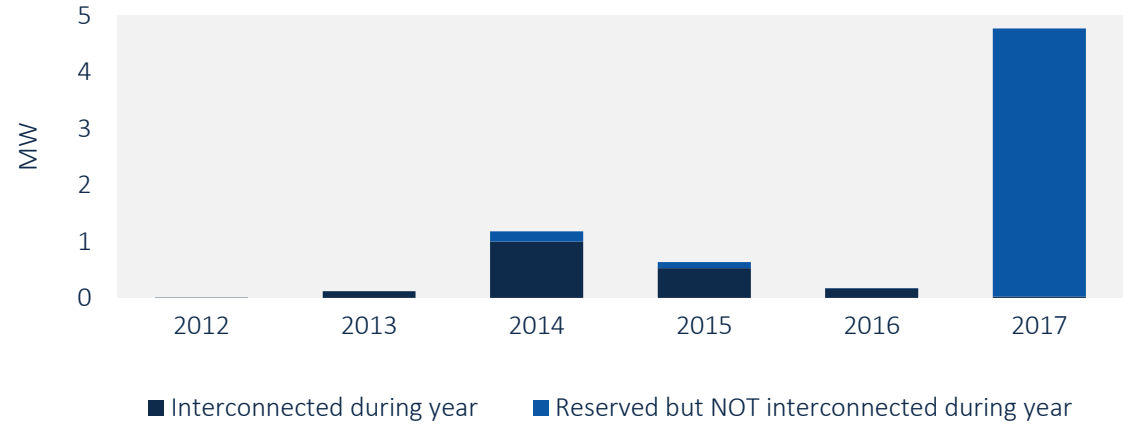


Source: GTM Research

Massive Influx of Residential SGIP Reservations as Program Pushes Forward in Q3 2017

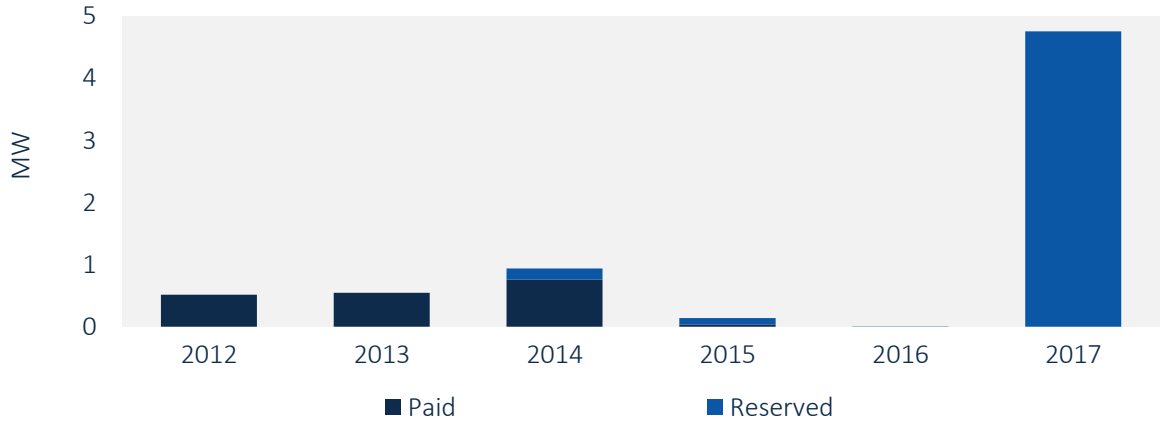
- The new iteration of the Self-Generation Incentive Program (SGIP) opened May 1, 2017. Step 1 was quickly subscribed across all four program administrators (CSE, PG&E, SCE and SCG), and as such the submitted projects entered into a lottery. Step 1 of the new program offers an incentive of $0.5/Wh and Step 2 offers $0.4/Wh for residential storage projects for up to 60% of eligible project costs. The previous iteration of the SGIP continues to see queue clearing. The final incentive level of the previous program was $1.31/W for up to 60% of eligible project costs.
- As of early November 2017, a total of 393 projects totaling 1.95 MW received an SGIP incentive, while an additional 5.04 MW had reserved funding, and 1.85 MW have been interconnected. 4.75 MW of projects received in 2017 have reserved funding, the majority of which was allocated in the past few months.
- The residential carve-out in the new iteration of the SGIP has proved instrumental in increasing the amount of funds reserved under the program, evidenced by the fact that within six months of the new program opening, the reserved residential capacity was roughly three times the entire reserved and paid capacity for the years 2013 through 2016. The residential carveout has ensured greater certainty for residential storage market players in California, given that funds are allocated specifically to their segment. Residential market players have indicated a more bullish outlook for the next few years given these changes. As a result, the share of residential projects in the overall SGIP ecosystem will increase substantially compared to previous years.

Interconnected vs. Reserved Capacity by Year (MW)



Source: CPUC (SGIP), GTM Research

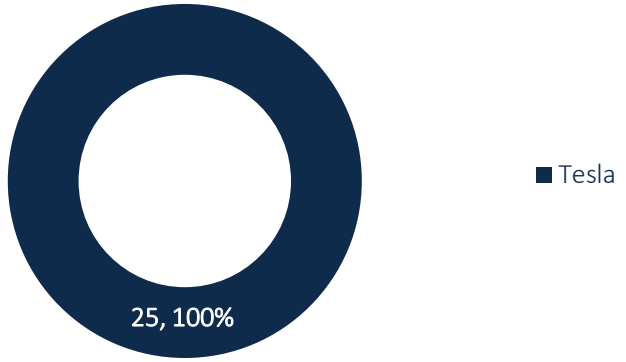
Paid vs. Reserved Capacity by Year of SGIP Application (MW)



Source: CPUC (SGIP), GTM Research

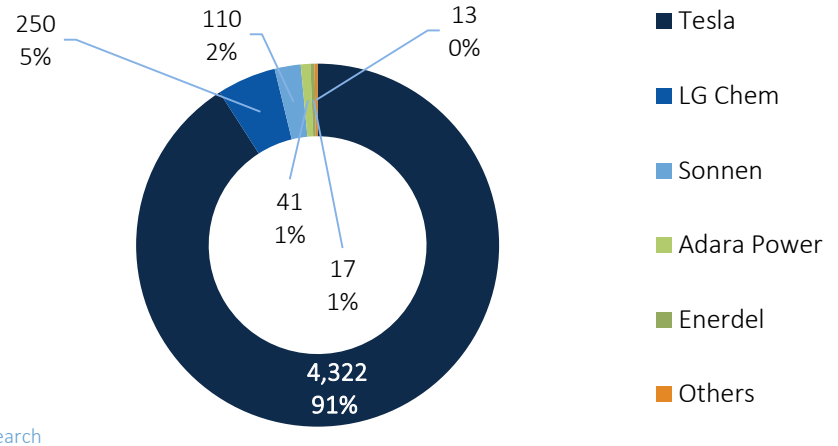
Massive Influx of Residential SGIP Reservations as Program Pushes Forward in Q3 2017 (Cont.)

Projects Interconnected in 2017, Residential (kW, % Vendor Market Share)



Source: CPUC (SGIP), GTM Research

Applications Received in 2017 With Reserved Funding, Residential (kW, % Vendor Market Share)



Source: CPUC (SGIP), GTM Research

- As of early November 2017, a total of 393 projects totaling 1.95 MW received an SGIP incentive, while an additional 5.04 MW had reserved funding, and 1.85 MW have been interconnected. 4.75 MW of projects received in 2017 have reserved funding, the majority of which was allocated between mid-September and early November 2017.
- So far in 2017, only 25 kW of residential storage have been interconnected, all of which was from Tesla. Now that a plethora of residential projects have reserved SGIP funds, more projects are expected to be deployed in the coming months.
- Tesla accounts for the largest share of reserved funding, with 91%, while LG Chem comes in second with 5%. Both companies offer storage systems used by a variety of players.
- The new SGIP has seen a massive spike in residential storage reservations compared to previous years, much of which is likely attributable to the residential carve-out. Such a funding allocation provides greater market certainty for residential players, and provides a massive boon to a segment which currently lacks clear economic drivers for deployment.

KIUC Files DER Management Plan to Build New NEM Mechanism

- In August 2017, the Kauai Island Utility Cooperative (KIUC) filed a distributed energy resources (DERs) management plan with the Hawaii Public Utilities Commission. The proposed program seeks to maximize the benefits of DERs on KIUC's grid by addressing challenges arising from increasing penetrations of DERs.
- Proposal includes two new rate tariffs options, which are similar to those adopted by HECO:
  - Customer Self-Supply: Customer agrees to not export any amount of electricity in excess of an inadvertent export standard. No compensation for electricity export. Encourages customers to adopt solar-plus-storage, as the only other alternative would be undersizing a solar system to ensure no next export.
  - Smart Export: Customer is only compensated for electricity exports at times when KIUC has determined the exports have value for the utility. Exported electricity compensated based on value at time of export. Customer must pair a solar PV system with a battery storage system to ensure compliance. Customer may use self-generated electricity to address the customer's own load, export during specific times of value for compensation, or store the energy in the battery for later use.
- As increasing levels of DERs are deployed, utilities will have to deal with challenges around intermittent generation, particularly export of rooftop solar onto the grid. HECO has already grappled with this challenge, and KIUC is employing a similar strategy for dealing with these challenges. If this new NEM structure is adopted, which seems likely given the Hawaii PUC's approval of HECO's program, KIUC will no doubt see a boom in storage deployments, as we are already seeing in HECO territory. Going forward under this regime, solar-plus-storage is effectively a given for new installations.

Net-Energy Metering Changes Continue in Florida, Hawaii and Nevada

Florida: JEA's NEM Program and Storage Rebate

- Insert textIn October 2017, the Jacksonville Electric Authority's updated net energy metering (NEM) program with battery storage incentives was approved. Program to take effect April 1, 2018. Would grandfather systems installed before March 31, 2018 into current NEM program, the deadline for grandfathering is June 31, 2018 if solar system is part of new home construction.
- Under new NEM program, customers credited at fuel rate for any exported solar energy. Fuel rate is roughly 3.4 cents/kWh vs. electricity rate of roughly 10.5 cents/kWh.
- Battery incentive would provide 30% rebate up to a maximum of $2,000 per household and $1M per year with no maximum program budget (it is not yet clear how many years program will run). Expected to lead to up at least 2.5 MWh of additional storage deployed annually, which is significant considering the miniscule level of deployments to date in Florida's residential storage market. Additionally, low NEM compensation and interest in resilience following recent hurricanes will further drive interest in storage adoption in JEA territory.

Nevada: PUCN Reinstates NEM

- In September 2017, the Public Utilities Commission of Nevada (PUCN) ordered the reinstatement of NEM. The order institutes AB 405, legislation passed in June 2017, which aims to restore favored NEM rates for solar customers (Docket 17-07026).
- Compensation set at 95% of the retail rate until 80 MW of solar are installed, at which point the export credit declines 7% until another 80 MW are installed, hitting a floor of 75% of the retail rate. Payment is guaranteed on a monthly basis.
- Lower NEM rates benefit storage economics by encouraging self-consumption, but compensation remains high enough that policy is a downside for the storage market. However, lower credits may push some customers to get storage for self-consumption.

Hawaii: Smart Export and CGS+ Programs

- In October 2017, the Hawaii PUC approved two new programs for customers seeking to deploy rooftop solar: Smart Export and Customer Grid Supply Plus (CGS+) as Decision and Order No. 34924 under Docket 2014-0192.
- Smart Export program: For customers installing solar-plus-storage, storage system will charge from solar PV between 9 a.m. and 4 p.m., option exists to export stored electricity to grid between 4 p.m. and 9 a.m. in exchange for a credit, export credit rates remain fixed for 5 years, program capacity of 35 MW (25 MW for HECO, 5 MW for HELCO, 5 MW for MECO, expected to serve 3,500 to 4,500 customers)
- CGS+: Successor to the original CGS program, allows for solar-only installations, electricity export to grid during daylight hours but also includes equipment to allow utility to manage electricity from the solar systems, credits have fixed rates for five years, program capacity of 49 MW (35 MW for HECO, 7 MW for HELCO, 7 MW for MECO, expected to serve 5,000 to 6,000 customers)
- New export programs will no doubt affect Hawaii's behind-the-meter storage market. The Smart Export program will help encourage solar-plus-storage adoption, as a new revenue stream can be gained by adequate export. The CGS+ program will aid in deployment of solar-only and assuage concerns from solar installers about the runway for their business, and the additional control will help address system concerns for Hawaii's grid. Additionally, it's likely some CGS+ systems will be paired with storage as we've seen with the CGS program. Most importantly, the program will provide valuable results for other states that have yet to grapple with high solar penetration the way we've seen in Hawaii, and will aid in developing proper export programs to ensure a stable electricity grid. Hawaii PUC has directed HECO to file tariffs, and thus the final program rates are expected in mid- to late December 2017.

Residential Market Outlook: Applications

GTM Research analysis suggests there will be three broad application areas for residential energy storage: time-of-use shifting, resiliency and backup, and grid and wholesale market services.

Time-of-use shifting: Most residential tariff regimes have flat tariffs, but a growing number of utilities are introducing time-of-use (TOU) tariff structures, some accelerated by the rise in solar NEM customers. As markets move to time-of-use tariffs or reduce the value of NEM, the economic case for adding storage to solar will become stronger. In California, the recent NEM 2.0 plan added non-bypassable charges of 2 to 3 cents/kWh on solar customers, as well as a mandatory TOU tariff. Both of these changes can increase the value of time-of-use shifting; however, neither provide sufficient value to cover for lifetime costs of operating storage. In order for broader storage adoption to occur, the costs would have to come down further, or these systems would need to tap into other value streams. SDG&E and PG&E both reached their NEM 1.0 caps in 2016, and thus it will be interesting to track storage adoption in these territories in the coming months. Furthermore, utilities in other states including Arizona, Colorado and New York have proposed or are in the process of implementing optional residential TOU rates, which may present additional opportunities for residential energy storage, depending on the delta between electricity cost at off-peak and peak periods.

Resiliency and backup: Residential customers do not necessarily have expensive equipment or critical facilities that require backup. However, customers have shown a willingness to pay for protection from outages, as evidenced by residential backup generation sales. States in the Northeast have established programs to increase grid resiliency, relying on energy storage, along with other upgrades. System vendors and installers consistently mention backup as a value stream of interest desired by end customers, particularly those in the Northeast U.S. In the wake of recent hurricanes affecting Puerto Rico, Texas and the Southeast U.S. the resilience conversation is expected to intensify and storage will increasingly be a part of these conversations.

Grid and wholesale market services: California utilities have been at the forefront of exploring the use of energy storage for grid services, including demand response, ancillary services and local capacity. SCE awarded 5 MW/20 MWh of residential energy storage under its PRP program in September 2016. The New York REV initiative has entered into its demonstration phase, in which several pilot projects involve energy storage. Hawaii recently introduced a demand response plan that proposes four grid services for which it could procure energy storage and other distributed resources. Utilities in the states of Kentucky and Vermont have also initiated grid services programs. Arizona has initiated multiple utility-sponsored residential solar-plus-storage programs to enable better utility load management and tariffs. Xcel Energy in Colorado is in the process of deploying an energy storage pilot that includes six residential systems to explore value that can be provided to both customers and the electric grid. Other utilities are entertaining opportunities to deploy residential storage, with more pilot programs expected to be announced in the coming year.

Residential Market Outlook: Markets

GTM Research's outlook on key residential markets is presented below.

Arizona: Arizona is in the throes of utility rate cases and NEM revisions, the results of which are expected to increase opportunities for storage, both by the implementation of new tariff structures including TOU rates and possible residential demand charges, as well as reducing the compensation for exported solar electricity, thus encouraging greater self-consumption. However, the end result of these proceedings remains unclear, so the size of upside for residential storage is cloudy. By 2022, Arizona will have a 40 MW annual market.

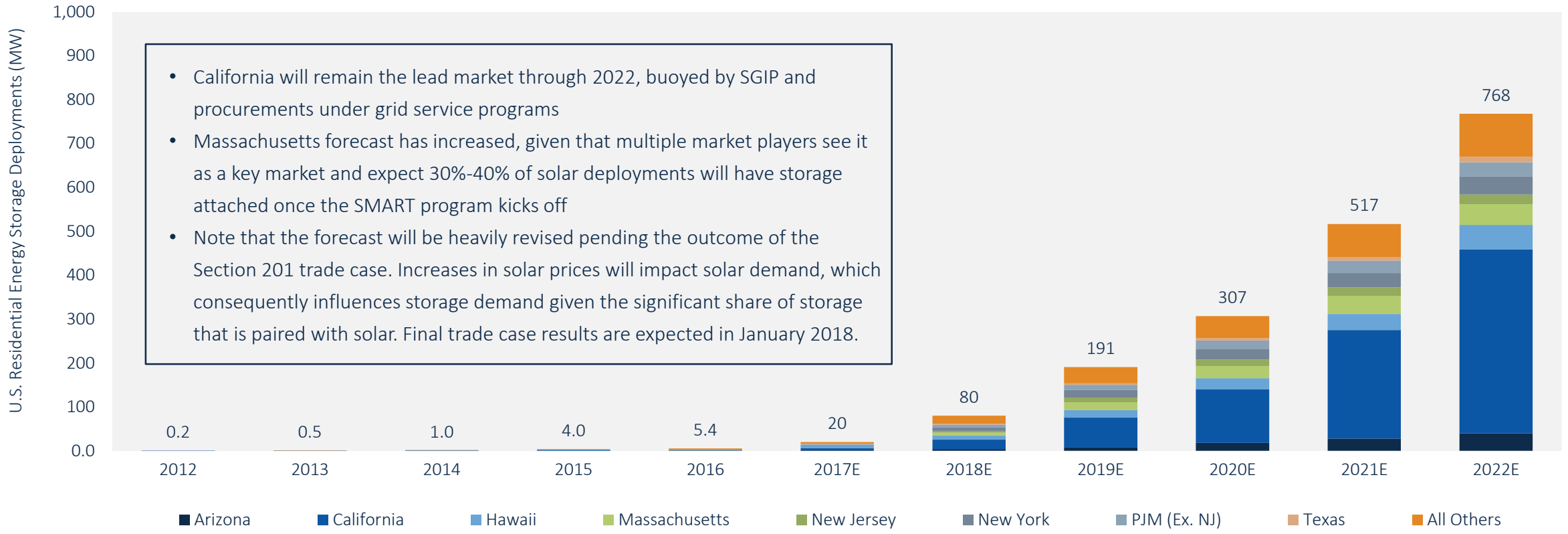
California: California will remain a leader in residential storage growth, particularly as the new iteration of the SGIP includes a carve out for residential storage; as a result, a greater share of residential projects is expected to be deployed under SGIP, which is already bearing out by deployment numbers from Q3 2017. With the coming of NEM 2.0, opportunities for storage are increasing as TOU rates and non-bypassable charges come into force alongside reduced compensation for exported solar energy. Furthermore, 5 MW/20 MWh of residential storage was procured under the Preferred Resources Pilot, with these systems set to come on-line by mid-2019. These factors will culminate in a 418 MW annual market by 2022, 331 times the size of the 2016 market.

Hawaii: Hawaii reopened its Customer Grid Supply (CGS) program in early 2017 with a 20 MW cap, putting a damper on the storage market, as the alternative tariff, Customer Self-Supply (CSS), encourages solar-plus-storage. As the new CGS cap was reached, all new solar customers must enroll in CSS. Q3 2017 saw a further rise of CSS, as a substantial number of storage systems were interconnected under this program. The new solar program will lead to a further upside for storage, because although CGS is reopening as CGS+, there is both a cap and a rule that credits can only be gained at specific hours, meaning customers on this tariff may also pursue storage, while the Smart Export tariff is configured for solar-plus-storage. Anecdotal discussions with system integrators, developers and installers active in Hawaii's residential energy storage market indicate a bullish outlook for the next few years. Hawaii's annual residential storage market is expected to reach 56 MW by 2022, 246 times the size of the 2016 annual market and roughly 10 times the size of the 2017 annual market.

The Northeast: The Northeast will continue to prove an interesting region for residential storage and constitute a non-trivial share of installations for resilience applications. However, given the lack of a clear economic case for backup power today, these deployments will remain concentrated among customers purchasing storage primarily for emotional reasons. This may change if residential storage systems are able to be leveraged for grid services such as peak load reduction, as is currently ongoing in Green Mountain Power territory in Vermont, although as a total addressable market, Vermont remains small. Con Edison's NY REV virtual power plant demonstration project, which would add ~300 new residential systems, is currently stalled, and thus it is unclear when or even if these systems will be added. Massachusetts is a market to watch, as the new solar program, SMART, begins in 2018 and includes an adder for solar systems paired with storage; anecdotal discussions with system vendors and installers indicate that Massachusetts will be a priority market in 2018 and 2019.

Residential Market Outlook (MW)

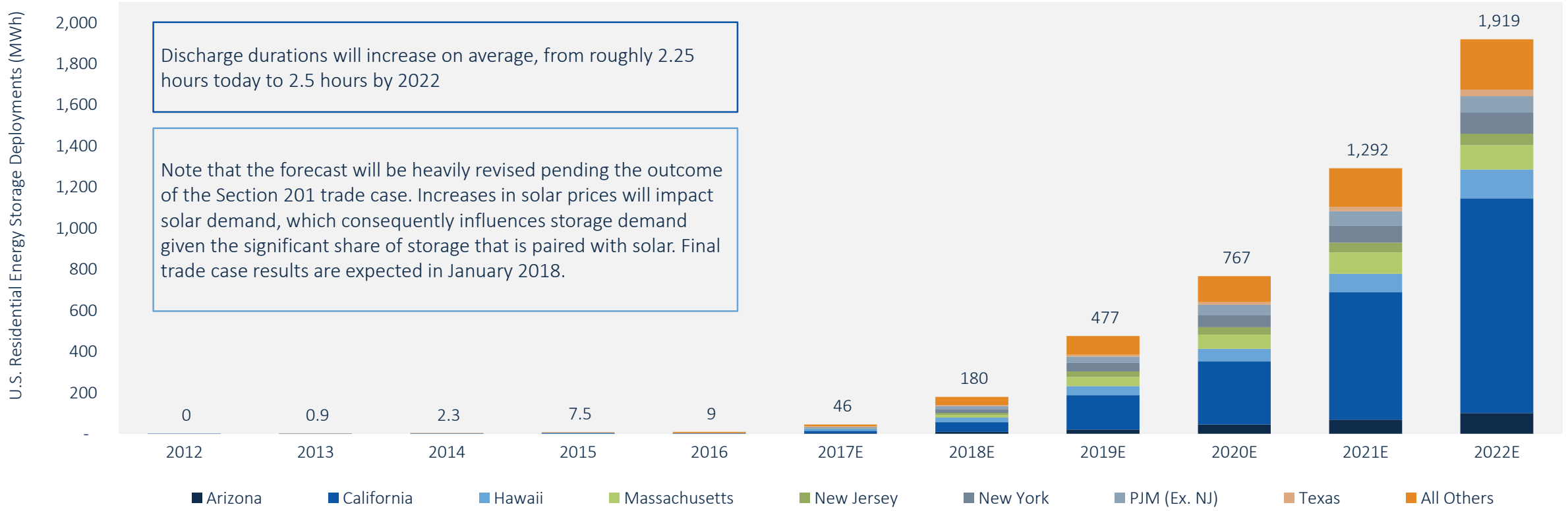
U.S. Annual Residential Energy Storage Deployment Forecast, 2012-2022E (MW)



Source: GTM Research

Residential Market Outlook (MWh)

U.S. Annual Residential Energy Storage Deployment Forecast, 2012-2022E (MWh)



Source: GTM Research

8. Appendices

Appendix A: Metrics, Methodology and Data Sources

- **Metrics:** GTM Research reports energy-storage capacity data in terms of power capacity (watts) and energy capacity (watt-hours). All of our data sources (details on data sources below), including program administrators, utility companies, utility commissions and system operators, currently track and report energy storage queue, deployments and interconnections in terms of power capacity: watts, kilowatts or megawatts. GTM Research reports storage capacity data in power capacity terms (watts, kilowatts or megawatts) based on the reported data, and in energy capacity terms (watt-hours, kilowatt-hours or megawatt-hours) using a mix of publicly available and survey data, and converting power capacity to energy capacity by multiplying by discharge duration (hours). This distinction is particularly important, as energy storage technology can be deployed for a wide range of discharge durations, from a few minutes (for applications such as power quality and frequency regulation) to a few hours (for applications such as bulk energy arbitrage).
- **Segments:** GTM Research reports the energy-storage capacity data in three segments: residential, non-residential and utility-scale. Projects that are deployed on the end-customer side of the meter (i.e., behind-the-meter) are reported as falling in either the residential or nonresidential segment. Projects that are deployed on the utility side of the meter (front-of-the-meter), irrespective of their size, are reported in the utility-scale segment.

Appendix A: Metrics, Methodology and Data Sources (Cont.)

- **Historical Deployment Data:** Quarterly capacity deployment data is collected from program administrators, system operators, utility companies and utility commissions. In some cases, the program administrators report incentive application and award payment dates instead of deployed dates. In such cases, GTM Research consults with the utility companies or estimates the most likely installation date, based on our knowledge of typical project installation cycles in various markets. For utility-scale projects, GTM Research maintains a database that tracks the status of planned and deployed utility-scale projects. GTM Research reports deployment dates based on their "interconnection" or "on-line date" from interconnection queue data maintained by ISOs and utility companies. In certain cases, GTM Research consults with project developers and installers to provide the project commissioning (deployment) date. GTM Research also utilizes the U.S. DOE Global Energy Storage Database for information on technology in instances in which the information is not received from our primary data sources.
- **System Price Data:** Reported system price data is not associated with specific projects deployed, since pricing data is considered to be sensitive by vendors and developers, given the number of projects that are being deployed and the varying project cycles. System price data is the outcome of GTM Research's bottom-up cost survey based on interviews with vendors across the value chain.

Appendix B: Acronyms

- **AB 2514:** California state law requiring the California Public Utilities Commission to adopt an energy storage procurement target. In October 2013, CPUC established an aggregate target of 1,325 MW by 2020 for PG&E, SCE and SDG&E.
- **APS:** Arizona Public Service, an Arizona investor-owned utility
- **BQDM:** Brooklyn-Queens Demand Management, a program in New York City to implement non-traditional technology to defer the need for a $1B substation
- **C&I:** Commercial and industrial
- **CHP (combined heat and power)*:** Generation of useful electric and heat energy using the same conversion system
- **CPUC:** California Public Utilities Commission
- **DER:** Distributed energy resource
- **DOD:** Depth of discharge
- **DOE:** United States Department of Energy
- **DOER:** Department of Energy Resources (Massachusetts)
- **DR (demand response)*:** Reduction of retail electricity end users' electric load in response to control or price signals
- **DRAM:** Demand Response Auction Mechanism, program to procure demand response in California
- **EE:** Energy efficiency
- **EPC:** Engineering, procurement and construction
- **ERCOT (Electric Reliability Council of Texas):** Independent system operator for most of Texas
- **ESDER (Energy Storage and Distributed Energy Resources):** California stakeholder initiative to develop rules for storage and other DER market participation

Appendix B: Acronyms

- **FERC:** Federal Energy Regulatory Commission
- **GW (Gigawatt):** Unit of energy storage capacity in power; 1,000 MW
- **GWh (Gigawatt-hour):** Unit of energy storage capacity in energy; 1,000 MWh
- **HECO:** Hawaiian Electric Company, a Hawaii IOU and subsidiary of Hawaiian Electric Industries
- **HELCO:** Hawaii Electric Light, one of the Hawaiian Electric Companies family that has jurisdiction over Hawaii Island
- **IRP:** Integrated Resource Plan
- **ISO (independent system operator):** Operates a region's transmission grid and wholesale electric markets, similar to a regional transmission organization (RTO)
- **IOU:** Investor-owned utility
- **JEA:** Jacksonville Electric Authority, a community owned electric utility located in Jacksonville, Florida
- **kW (kilowatt):** Unit of energy storage capacity in power; 1,000 W
- **kWh (kilowatt-hour):** Unit of energy storage capacity in energy; 1,000 Wh
- **LCR (local capacity requirements):** Minimum local resource capacity needed for reliability in an area
- **MUA:** Multiple-use applications
- **MECO:** Maui Electric, one of the Hawaiian Electric Companies family that has jurisdiction over the island of Maui, Molokai and Lanai
- **MW (Megawatt):** Unit of energy storage capacity in power; 1,000 kW
- **MWh (Megawatt-hour):** Unit of energy storage capacity in energy; 1,000 kWh
- **NOPR:** Notice of proposed rulemaking

Appendix B: Acronyms

- **NWA:** Non-wires alternative, a technology that can fulfill an electric grid upgrade in place of traditional technology
- **NY REV (Reforming the Energy Vision):** State policy aimed at increasing deployment of renewable generating resources and modernizing the grid
- **NYSERDA:** New York State Energy Research and Development Authority
- **PCS:** Power conversion system or power conditioning system – typically referencing power electronics converting DC to AC at a point of interconnection
- **PG&E:** Pacific Gas & Electric, a California IOU
- **PJM:** RTO for all or parts of 13 states (from Illinois to New Jersey) and the District of Columbia
- **PRP (Preferred Resource Pilot):** SCE's study to determine if clean energy sources can offset increasing customer demand
- **PSC:** Public Service Commission
- **PSCo:** Public Service Company of Colorado, Xcel Energy subsidiary
- **PUC:** Public Utilities Commission
- **RegD:** PJM's classification for fast-responding ("dynamic") resources
- **RFI/RFO/RFP:** Request for information/request for offer/request for proposal
- **RPS (renewable portfolio standard):** Regulatory requirement mandating a particular amount of renewables in the jurisdiction's electricity mix
- **RTO (regional transmission organization):** Operates a region's transmission grid and wholesale electric markets, similar to an ISO
- **SCE:** Southern California Edison, a California IOU
- **SDG&E:** San Diego Gas & Electric, a California IOU
- **T&D:** Transmission and distribution
- **TEP:** Tucson Electric Power, an Arizona IOU

Appendix C: Key Documents

Arizona

- APS Proposed Large General Service Time-of-Use Storage Program Tariff documentation

California

- AB 546
- CPUC Decision on SGIP Equity Budget
- CAISO ESDER Phase 3
- SB 338

Connecticut

- CT DEEP Microgrid Program

Federal

- S. 1851
- S. 1868
- S. 1875
- S.2041

Florida

- JEA NEM and Battery Incentive Proposal
- Duke Settlement Announcement

Hawaii

- Docket 2014-0192
  - Decision and Order No. 34924
  - Smart Export and CGS+ Program Announcement
  - Fact Sheet
- KIUC DER Program Proposal
- HECO Grid Modernization

Massachusetts

- DPU 17-146

Appendix C: Key Documents (Cont.)

Nevada

- Nevada PUC Net Metering Portal
  - PUC Decision on Net Metering

New York

- NYISO DER Pilot Program Guide

Oregon

- PGE submits storage plan to Oregon Public Utilities Commission

Washington

- Washington State Utilities and Transportation Commission Policy Statement on Storage

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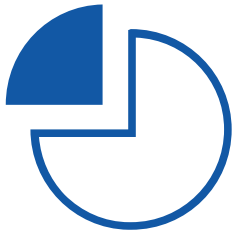

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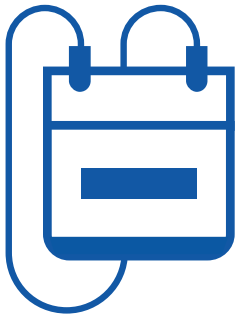
GTM Research is the leading market analysis and advisory firm on the transformation of the global electricity industry. Our team provides critical and timely market analysis in the form of research reports, data services and consulting.



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