U.S. energy storage monitor

2018 Year in review and Q1 2019 executive summary

Wood Mackenzie Power & Renewables / Energy Storage Association | March 2019

Contents (full report)

About this report

The U.S. energy storage monitor is a quarterly publication of Wood Mackenzie Power & Renewables 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:

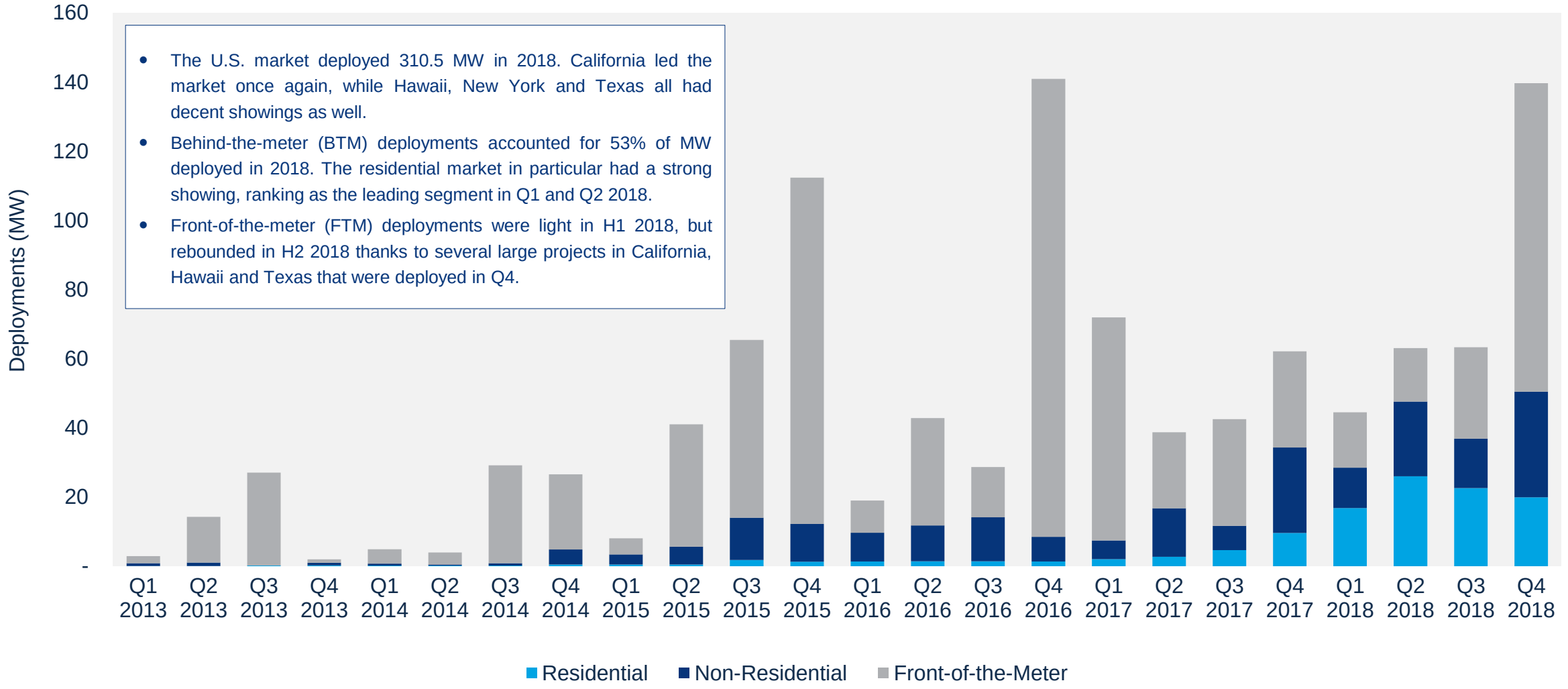
- All forecasts are from Wood Mackenzie Power & Renewables; ESA does not predict future pricing, costs or deployments.
- References, data, charts and analysis from this report should be attributed to “Wood Mackenzie Power & Renewables/ESA U.S. energy storage monitor”
- Media inquiries should be directed to Chloe Holden from Wood Mackenzie Power & Renewables (Chloe.Holden@woodmac.com) or Tori Montano with the Energy Storage Association (202.765.2803)

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

U.S. 2018 deployments rose 44% from 2017 (MW)

Market more than doubled from Q3 2018 to Q4 2018 as FTM market surged forward

- The U.S. market deployed 310.5 MW in 2018. California led the market once again, while Hawaii, New York and Texas all had decent showings as well.
- Behind-the-meter (BTM) deployments accounted for 53% of MW deployed in 2018. The residential market in particular had a strong showing, ranking as the leading segment in Q1 and Q2 2018.
- Front-of-the-meter (FTM) deployments were light in H1 2018, but rebounded in H2 2018 thanks to several large projects in California, Hawaii and Texas that were deployed in Q4.

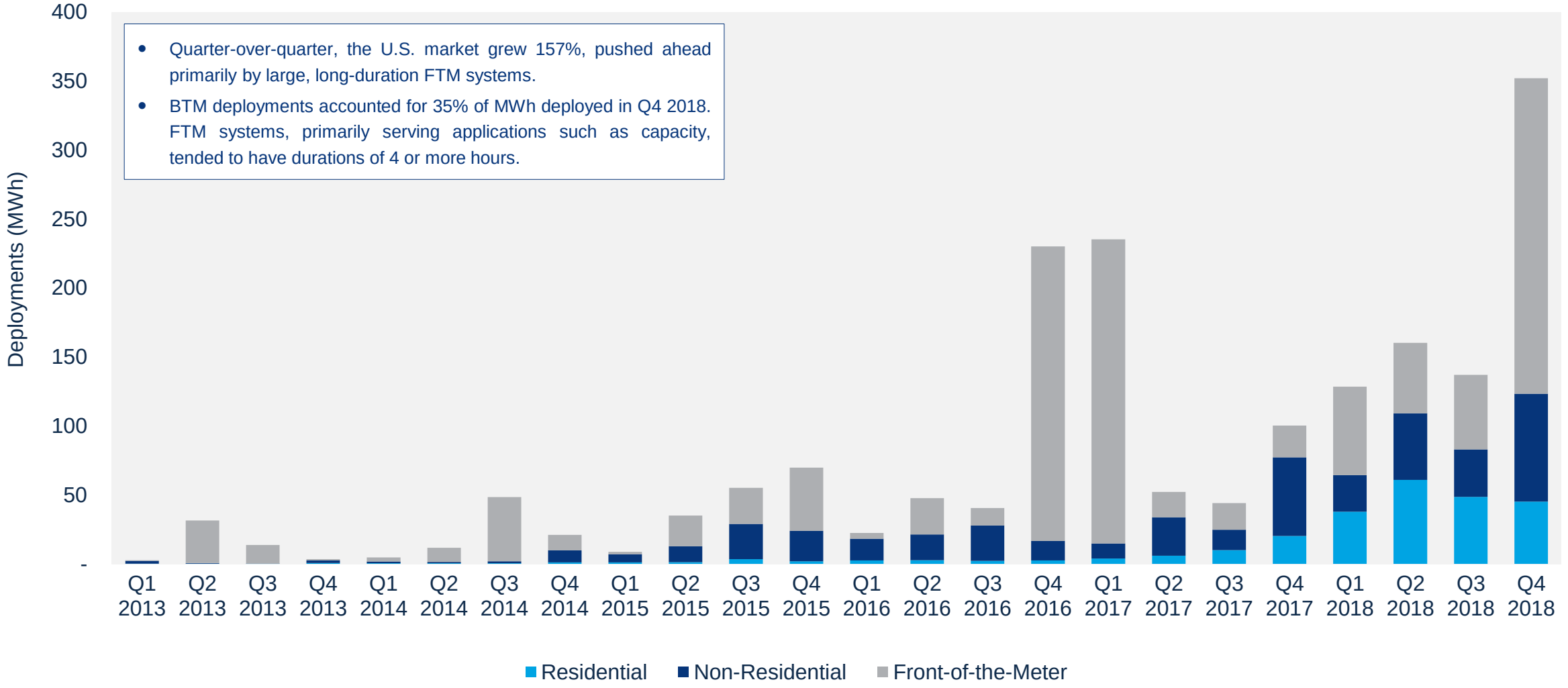


Source: Wood Mackenzie Power & Renewables

777 MWh of storage deployed in the U.S. in 2018, growing 80% from 2017

Q4 2018 surpassed previous MWh record by 50%

- Quarter-over-quarter, the U.S. market grew 157%, pushed ahead primarily by large, long-duration FTM systems.
- BTM deployments accounted for 35% of MWh deployed in Q4 2018. FTM systems, primarily serving applications such as capacity, tended to have durations of 4 or more hours.



Source: Wood Mackenzie Power & Renewables

Top energy storage markets, 2018

California leads across all segments

Top 3 markets by segment in 2018 (power capacity)

Rank	Residential	Non-residential	Front-of-the-meter
1	California	California	California
2	All others*	Hawaii	All others*
3	Hawaii	New York	Hawaii

Source: Wood Mackenzie Power & Renewables

Note: Wood Mackenzie Power & Renewables is currently monitoring 10 individual markets: Arizona, California, Colorado, Hawaii, Massachusetts, Nevada, New Jersey, New York, PJM and Texas

Front-of-the-meter policy and market developments, Q1 2019

ISO proceedings

CAISO and **MISO** continue to examine storage as a transmission asset and the potential to participate in markets under a cost-recovery model. **CAISO** is also proceeding with efforts to simplify and expedite the interconnection process for energy storage.

Nevada

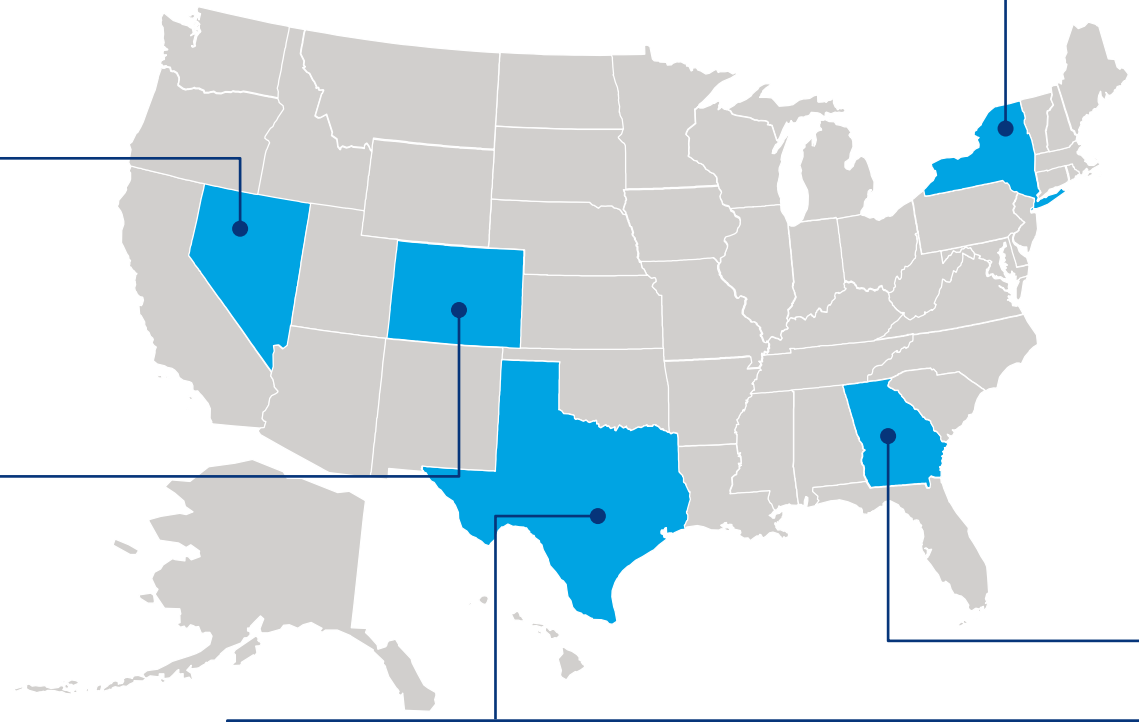
The Nevada PUC issued an order accepting a commissioned report pursuant to SB 204 recommending that an energy storage target is in the state's best interest.

Colorado

The Colorado PUC issued an order pursuant to HB 18-1270 establishing mechanisms and requirements for utilities to consider energy storage in resource planning.

Federal / national

NARUC issued a resolution on modeling energy storage and other flexible resources. Comments are in for **FERC Order 841**, with changes and approval scheduled around a December 2019 effective date.



New York

NYSERDA issued its storage order, initiating policy proceedings to support storage in the state. **NY PSC** published two white papers suggesting modifications to compensation under VDER. The **New York Green Bank** RFPs are ongoing

Puerto Rico

PREPA's draft integrated resource plan includes multiple scenarios, all of which include significant quantities of energy storage and solar.

Georgia

Georgia Power's latest RFP procuring renewable energy includes eligibility for energy storage in predetermined participation models.

Texas

El Paso Electric released an RFP for renewable energy including energy storage. **ERCOT** is undertaking the first significant overhaul of its ancillary services market, with significant upside for storage. In the **PUC of Texas'** report on the state of competition in the energy markets, the commission defers to the state legislature on the question of whether energy storage is "generation" for the purposes of distribution utility ownership.

Source: Wood Mackenzie Power & Renewables

Behind-the-meter policy and market developments, Q1 2019

Oregon

Portland General Electric proposed a 525-unit residential storage pilot to leverage systems for grid services.

California

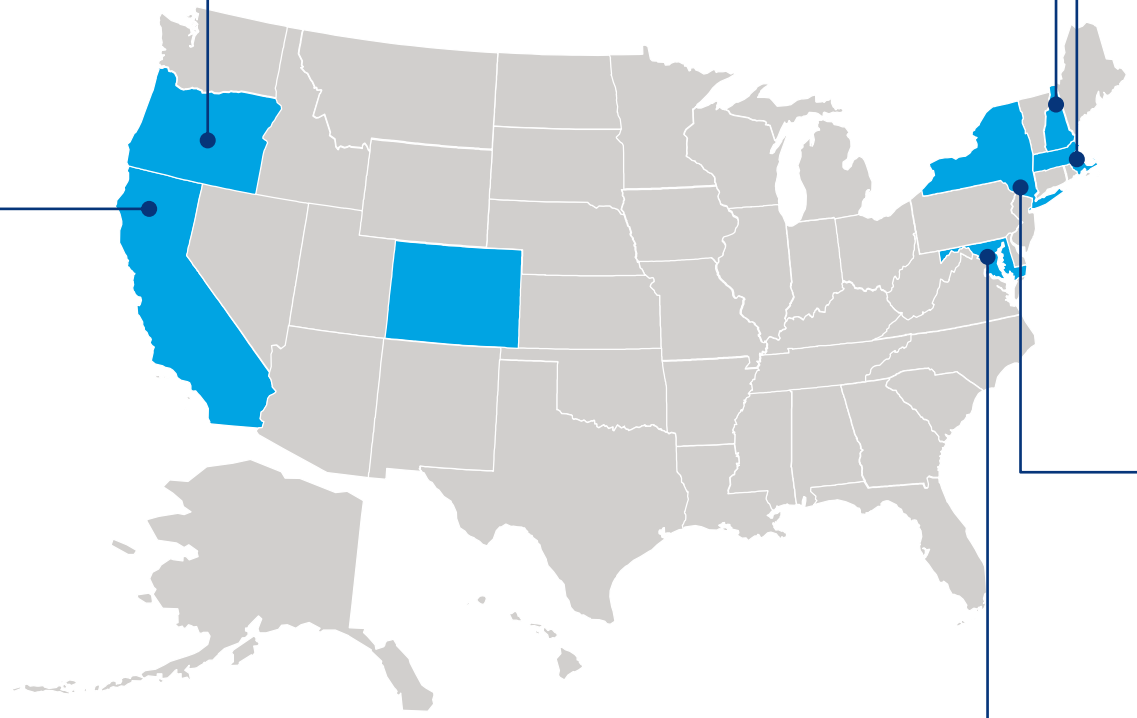
CPUC issued proposed rules for GHG emissions required under the Self-Generation Incentive Program; also issued a decision allowing energy storage systems paired with solar to take net metering service.

Federal / national

NARUC issued a resolution on modeling energy storage and other flexible resources. Comments are in for **FERC Order 841**, with changes and approval scheduled around a December 2019 effective date.

New Hampshire

The state **PUC** approved Liberty Utilities' residential storage pilot.



Massachusetts

Department of Energy Resources (DOER) announced the second block of the storage adder under Solar Massachusetts Renewable Tariff (SMART). **Department of Public Utilities** issued orders clarifying eligible net-metered solar-plus-storage system configuration and capacity rights under SMART; also issued an approval of 3-year efficiency filings, which will ultimately result in a storage incentive under the program

New York

NYSERDA issued its storage order, initiating policy proceedings to support storage in the state. **NY PSC** published two whitepapers suggesting modifications to compensation under VDER.

Maryland

MEA opened its Resiliency Hub Grant program to provide up to $5 million in funding for solar-plus-storage to serve buildings providing resilience for low and moderate income communities.

Source: Wood Mackenzie Power & Renewables

2018 laid the foundation for U.S. market expansion in 2019

On the whole, 2018 saw market growth over 2017, rising 44% year-over-year. This past year saw a number of market developments that laid out the groundwork for further market expansion and new business-model development in 2019. These developments include:

1. **FERC Order 841 filings that expand the opportunities for storage participation in wholesale markets**
2. **Programs that implement residential storage to provide grid services, creating new revenue streams for a segment historically limited to backup power**
3. **Record low solar-plus-storage PPA pricing that illustrates the technology continues to compete head-to-head with incumbent generation**
4. **Battery supply shortages, which plagued the market in 2018, are set to abate in early 2019, which will alleviate system pricing issues**

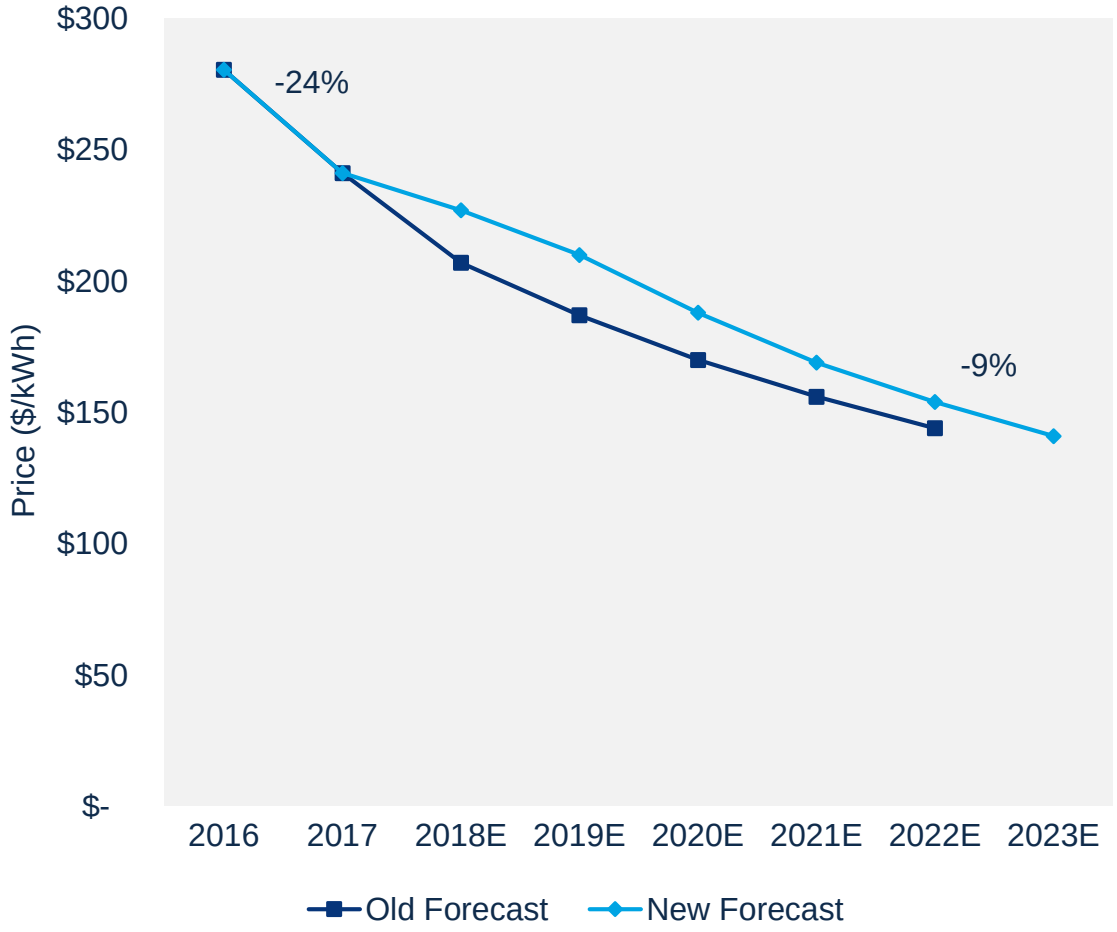
Taken together, such activity portends a momentous 2019. It's clear that opportunities for storage continue to expand, a positive feedback loop that will continue its progress as storage participation opportunities proliferate and system prices continue their downward slide.

The full report includes discussions of all four of these topics.

2018 was the year of lithium-ion battery rack supply shortages

While battery availability was a challenge in 2018, conditions are expected to improve by the end of H1 2019

Battery rack price forecast, 2016-2023E ($/kWh)



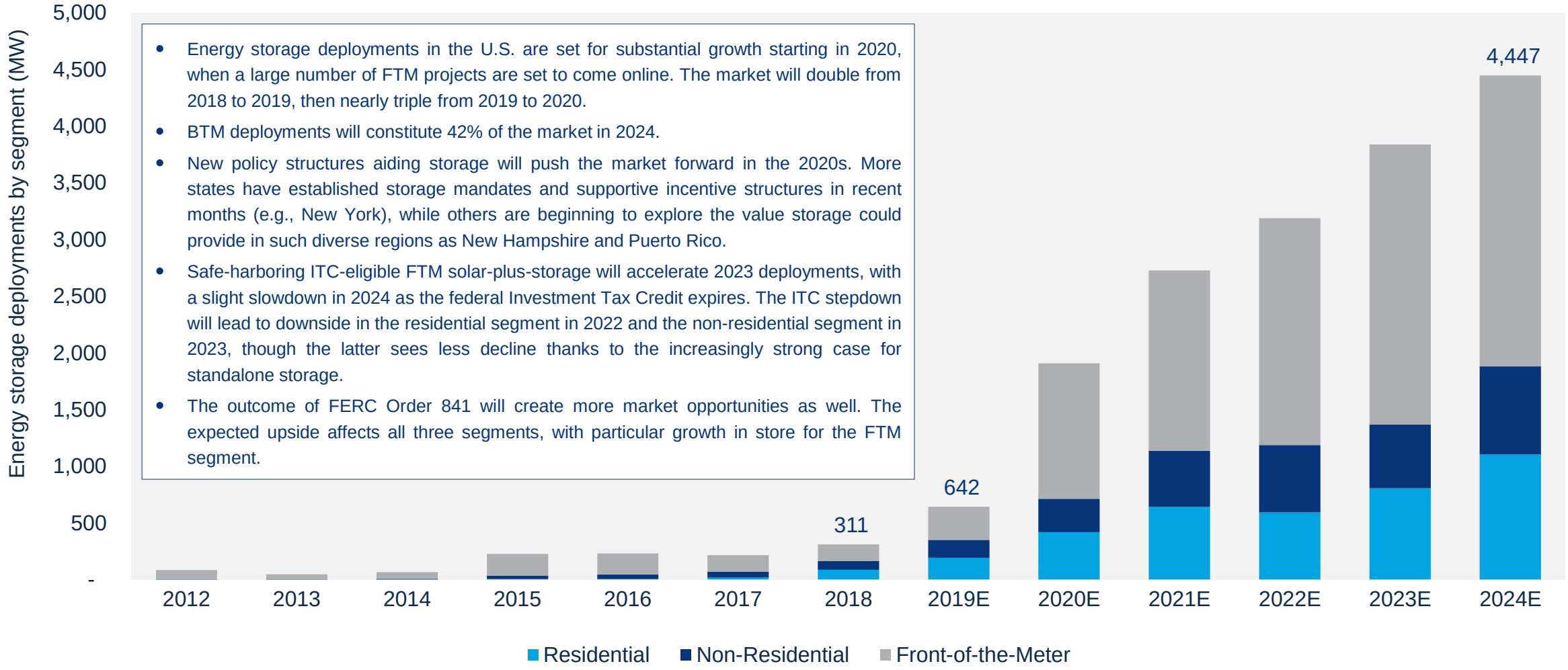
Source: Wood Mackenzie Power & Renewables

- Earlier in 2018, Wood Mackenzie P&R forecasted battery prices to decline by 14% over the course of the year. However, the pace of price declines slowed down dramatically once the market was hit by battery supply shortages in Q2 2018.
- 2018 saw demand for NMC batteries, from both EVs and energy storage industry, outstripping the supply, as cell manufacturing capacity couldn't keep up with the rapidly growing demand. While there was shortage of nickel-manganese-cobalt-oxide (NMC) batteries in the market, there were plenty of lithium-iron-phosphate (LFP) batteries available, with capacity being mostly housed in China. As lead times for NMC availability grew and prices stayed flat, by Q3 2018 LFP vendors began tapping into NMC-constrained markets at fairly competitive prices, thus making these LFP batteries an attractive option for both power and energy applications.
- Acknowledging the growing demand for batteries, by Q4 2018 several Tier 1 battery vendors announced new cell manufacturing plants and are currently on track to ramping up their production.
- As greater production capacity comes online battery, supply constraints will be resolved, likely by the end of H1 2019. With vendors realizing economies of scale, improvements in battery energy density and increasing market competition, battery prices will come down much faster in 2019. Our updated battery rack price forecast shows that over the next five years battery rack prices will drop below $150/kWh.

U.S. energy storage annual deployments will reach 4.4 GW by 2024

Utility procurements, changing tariffs and grid service opportunities all drive the market forward

U.S. energy storage annual deployment forecast, 2012-2024E (MW)



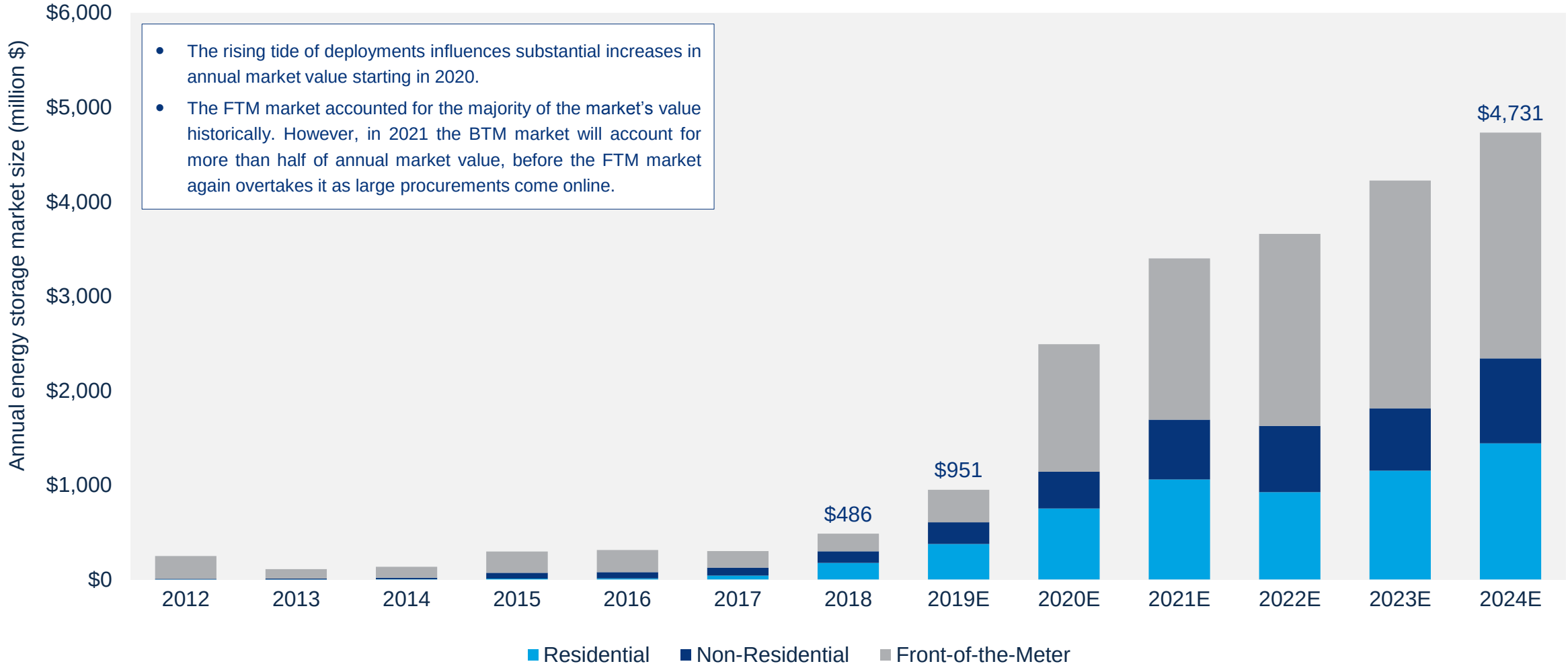
- Energy storage deployments in the U.S. are set for substantial growth starting in 2020, when a large number of FTM projects are set to come online. The market will double from 2018 to 2019, then nearly triple from 2019 to 2020.
- BTM deployments will constitute 42% of the market in 2024.
- New policy structures aiding storage will push the market forward in the 2020s. More states have established storage mandates and supportive incentive structures in recent months (e.g., New York), while others are beginning to explore the value storage could provide in such diverse regions as New Hampshire and Puerto Rico.
- Safe-harboring ITC-eligible FTM solar-plus-storage will accelerate 2023 deployments, with a slight slowdown in 2024 as the federal Investment Tax Credit expires. The ITC stepdown will lead to downside in the residential segment in 2022 and the non-residential segment in 2023, though the latter sees less decline thanks to the increasingly strong case for standalone storage.
- The outcome of FERC Order 841 will create more market opportunities as well. The expected upside affects all three segments, with particular growth in store for the FTM segment.

Source: Wood Mackenzie Power & Renewables

U.S. energy storage will be a $4.7 billion market in 2024

Value set to grow 5x between 2018 and 2020

U.S. annual energy storage market size, 2012-2024E (million $)



Source: Wood Mackenzie Power & Renewables. Note: Market size is reported as energy storage system deployment revenues (product of deployments and installed system prices).

U.S. energy storage monitor

Produced in a collaboration between Wood Mackenzie Power & Renewables and the Energy Storage Association (ESA), the *U.S. energy storage monitor* is the industry's only comprehensive quarterly research report on energy storage markets, deployments, policies, financing and regulations in the U.S. The report is available for purchase quarterly or as an annual subscription.

Executive summary vs. full report content

Content	Executive summary	Full report
Energy storage deployments	National aggregate	By state and market segment
Technology coverage	Deployments by technology	Status by technology
Market trends	National highlights	Detailed analysis
Pricing data	Not available	Quarterly index
Deployment forecast	National aggregate	By state and segment

Report pricing

Member status	Executive summary	Full report (PDF Enterprise License)	
		Individual quarterly report	Annual subscription (4 reports)
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Ravi has over 10 years of experience in energy storage as a consultant, analyst and engineer.

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