

# U.S. Energy Storage Markets: Applications, Technologies and Outlook

Prepared For:



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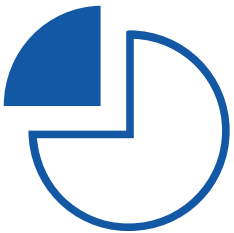
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# About Greentech Media



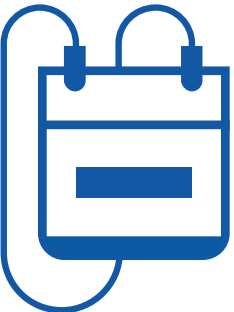
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Greentech Media delivers business-to-business news, analysis and events at the forefront of the global energy transformation. Our coverage area extends across the clean energy industry with a focus on solar power and the electric utility market's evolution. Greentech Media's industry-leading coverage is provided by a team of analysts from our market intelligence arm, GTM Research, as well as our world-class journalists and global network of expert contributors.



## Research

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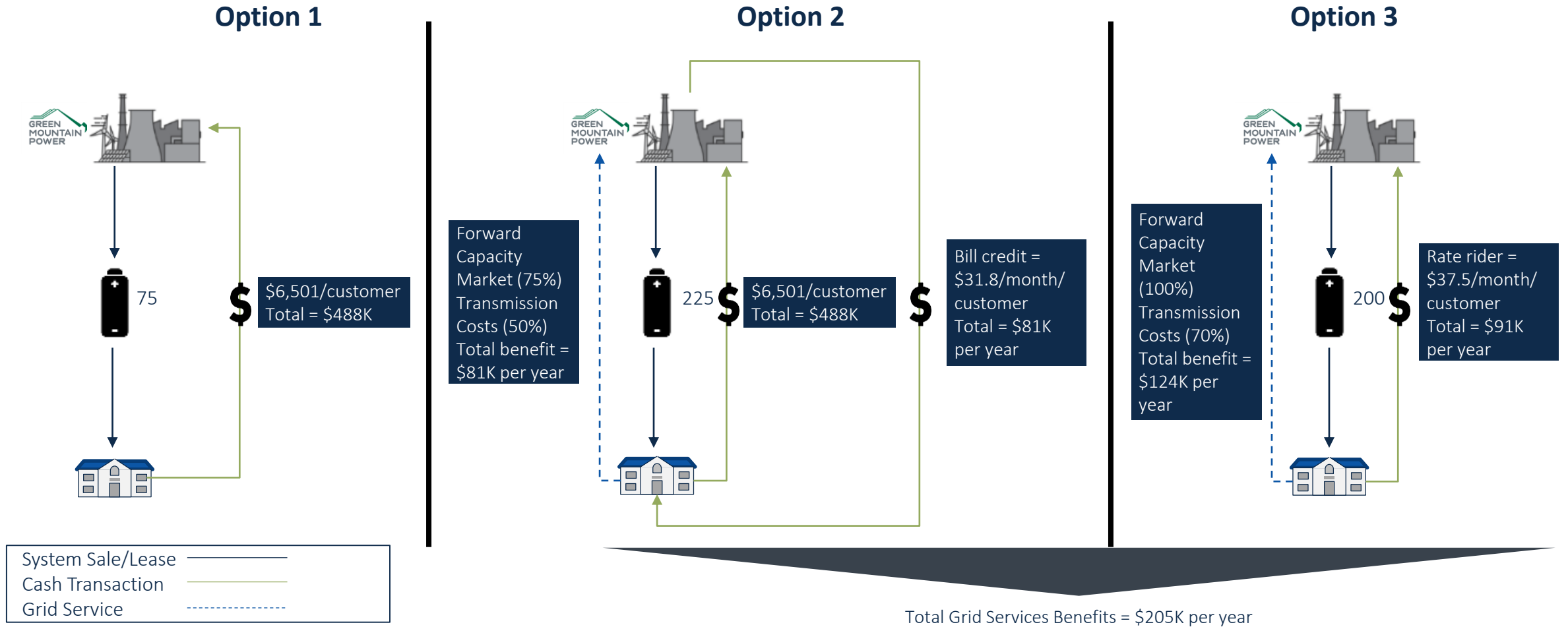


## Event

Greentech Media and GTM Research experts come together to produce all of Greentech Media's industry conferences throughout the year. These summits provide a platform for our latest market intelligence and draw together the industry influencers from organizations across the value chain.

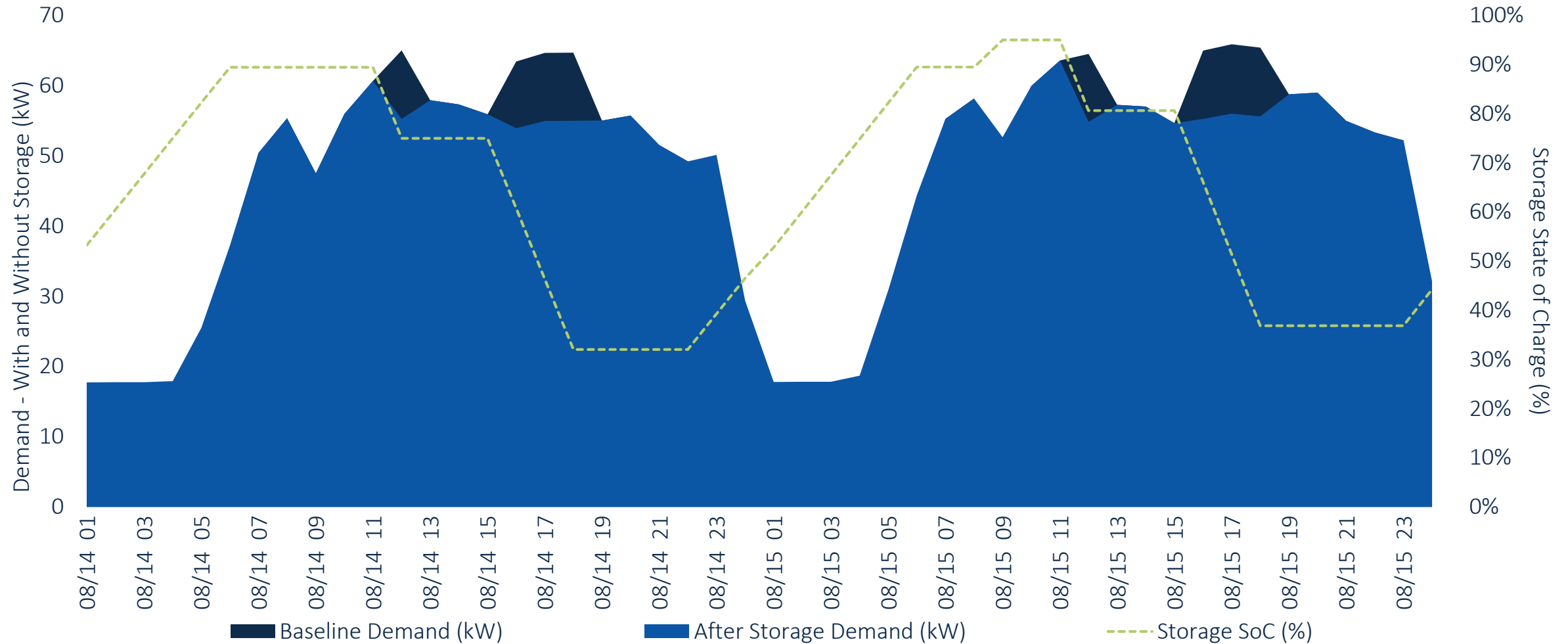
# Case Studies Are Worth Thousand Deployments...

# Residential Case Study: Green Mountain Power to Use Behind-the-Meter Storage to Reduce Peak Capacity and Transmission Costs



Source: Green Mountain Power, GTM Research

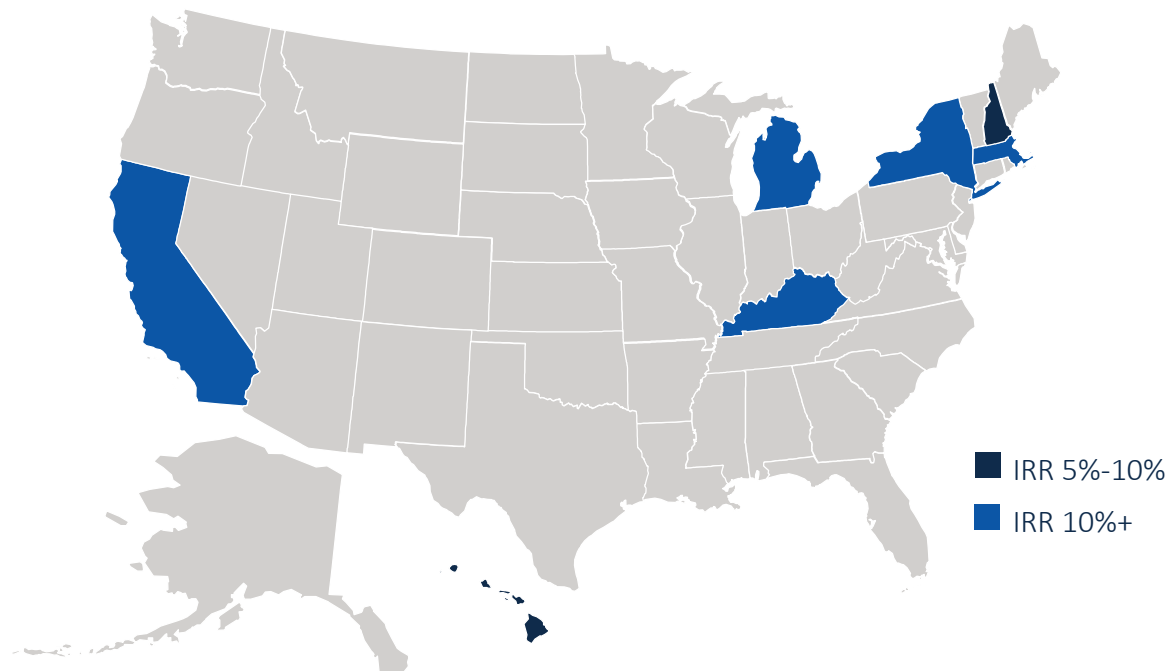
# Non-Residential Case Study: Demand Reduction for a Commercial Customer → Bill Savings Opportunity



Source: GTM Research The Economics of Commercial Energy Storage in the U.S.: The Outlook for Demand Charge Management

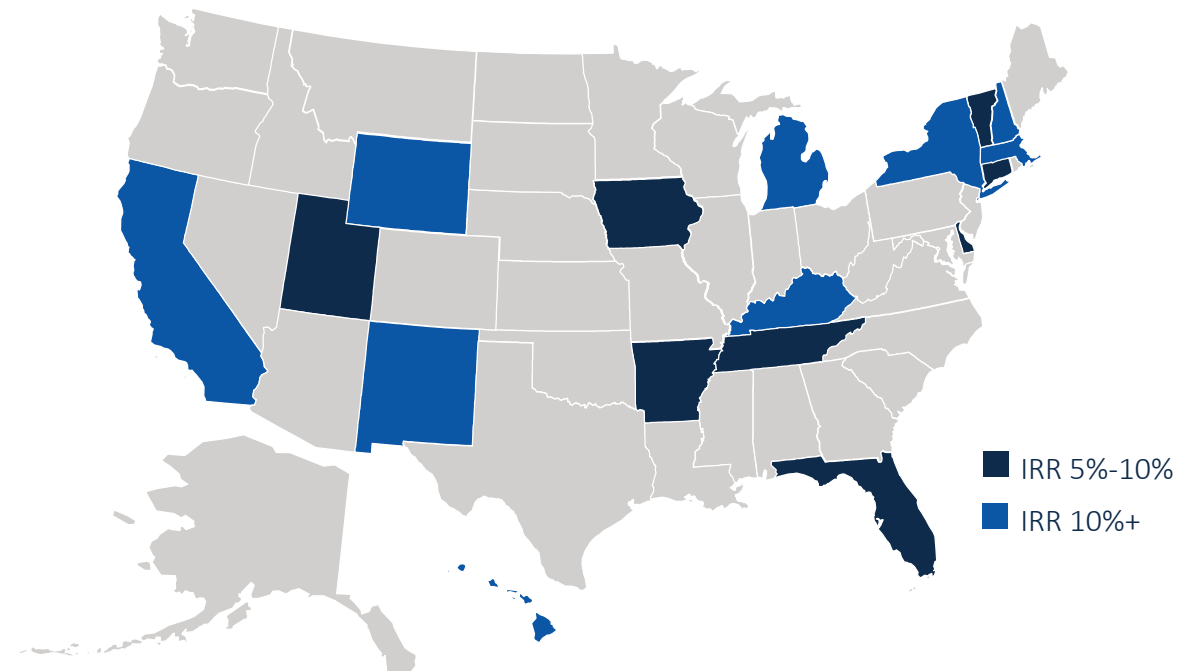
# Non-Residential Case Study: Medium C&I Energy Storage Returns Above 5 Percent in Seven Utilities in 2016, in 17 Utilities in 2021 (Base Case)

2016 C&I Energy Storage Economics



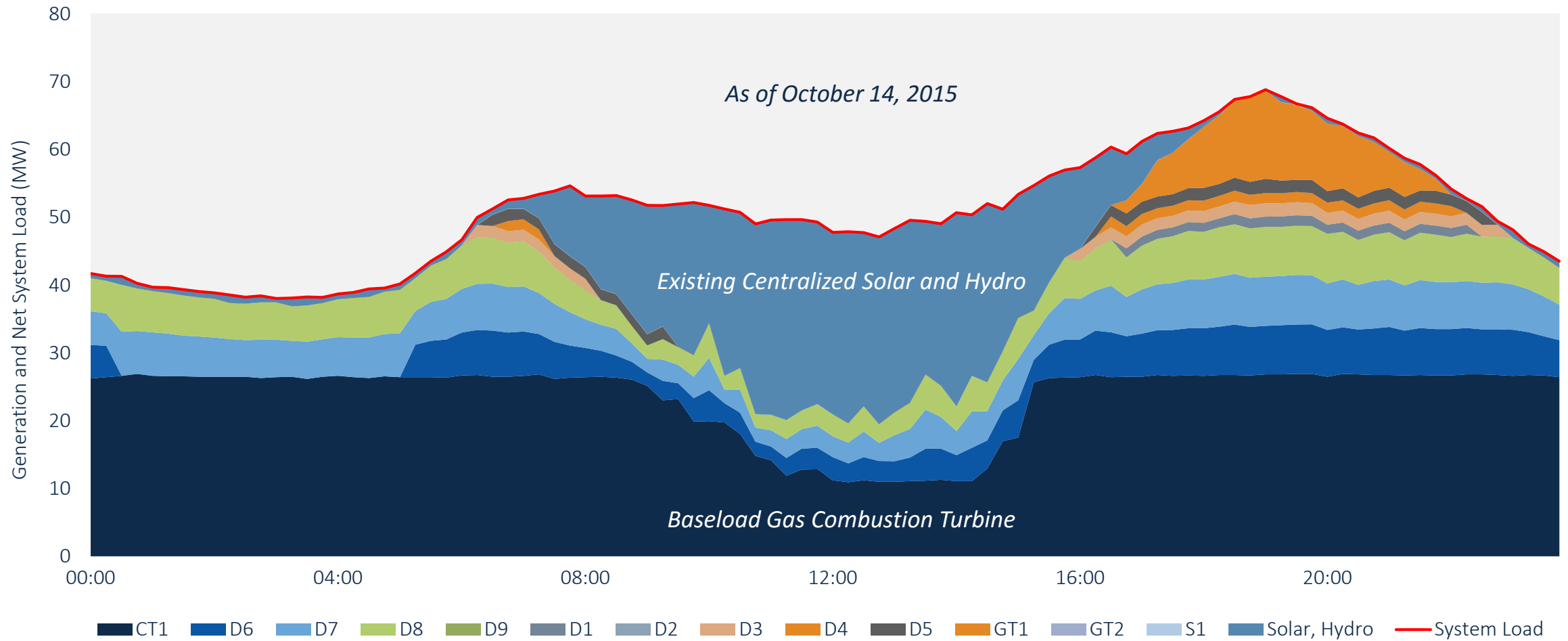
Source: GTM Research The Economics of Commercial Energy Storage in the U.S.: The Outlook for Demand Charge Management

2021 C&I Energy Storage Economics (Base Case)



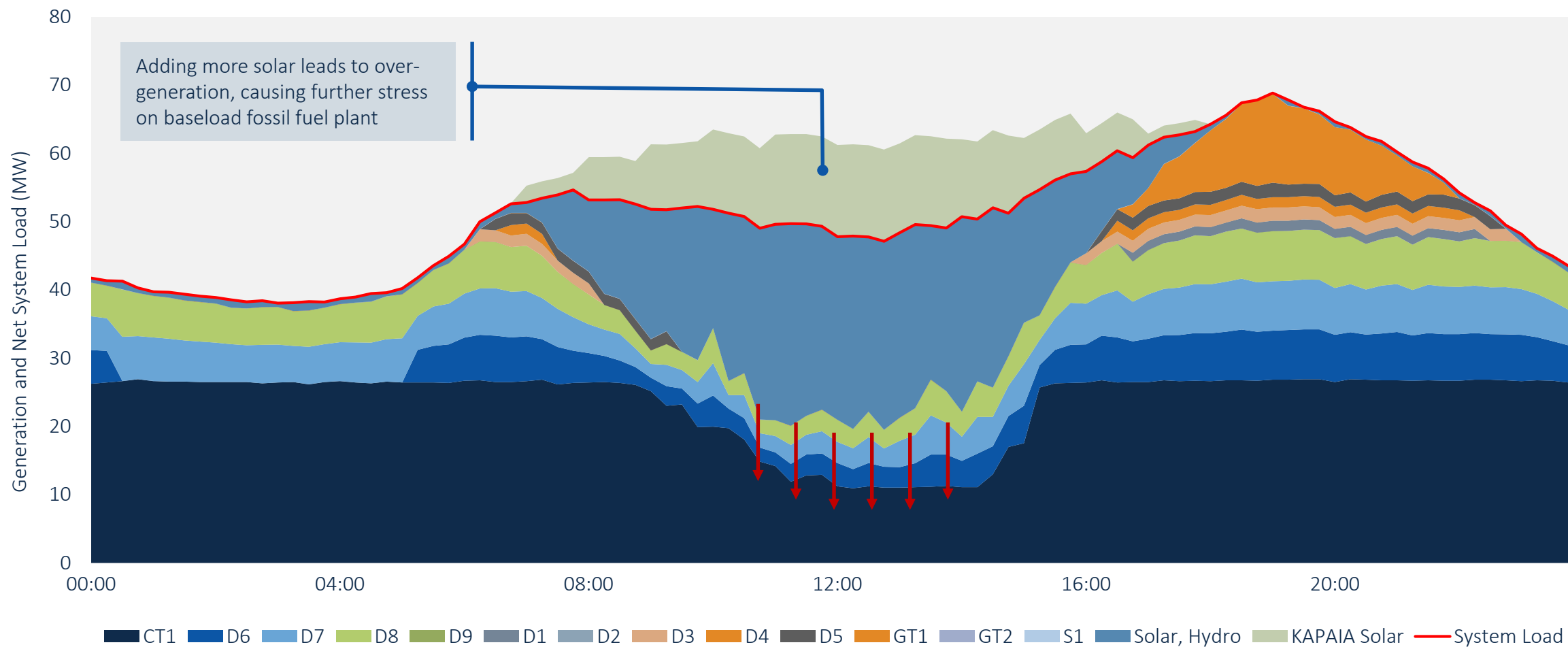
Source: GTM Research The Economics of Commercial Energy Storage in the U.S.: The Outlook for Demand Charge Management

# Utility Case Study: KIUC Centralized Generation and Net Load Today



Source: KIUC, GTM Research. CT = Combustion turbine, D = Diesel engine, GT = Gas turbine, S = Steam turbine.

# Utility Case Study: KIUC Centralized Generation and Net Load 13 MW Kapaia Solar Plant Addition

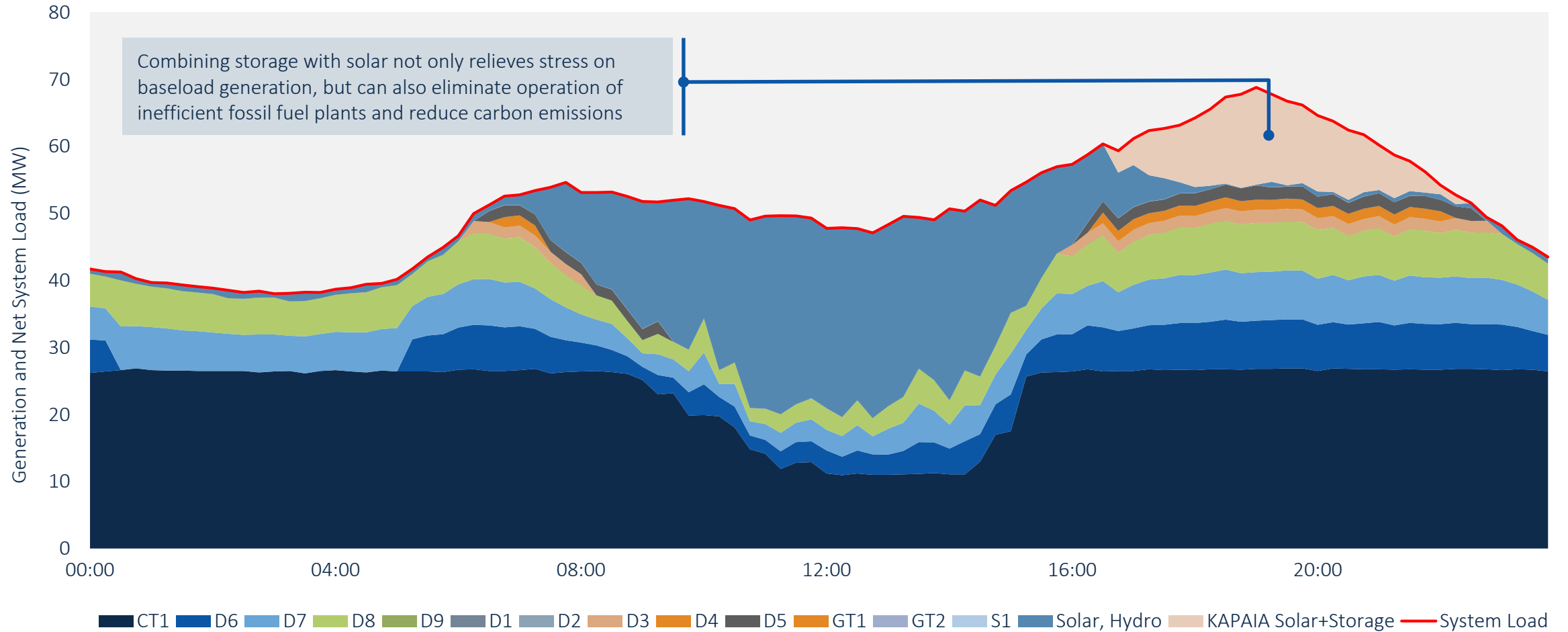


Source: KIUC, NREL PVWatts, GTM Research. CT = Combustion turbine, D = Diesel engine, GT = Gas turbine, S = Steam turbine.



# Utility Case Study: KIUC Centralized Generation and Net Load

## 13 MW Kapaia Solar Plant Plus 13 MW/52 MWh Storage Plant Addition

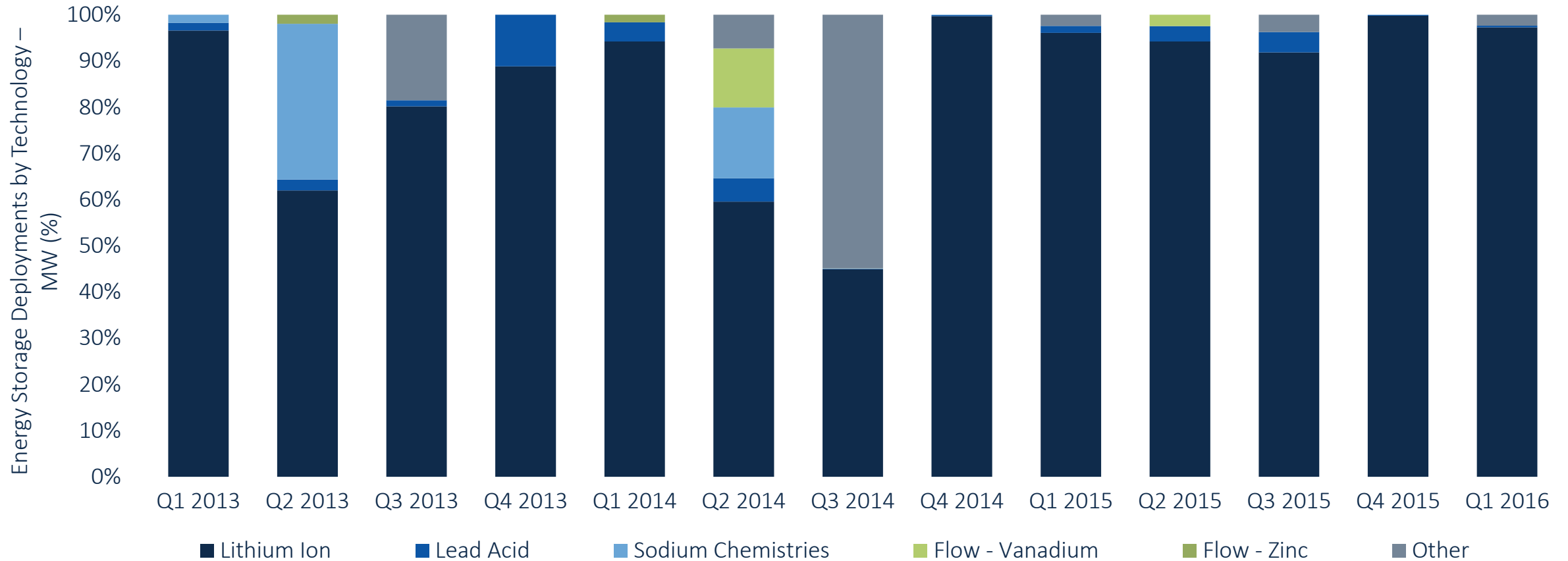


Source: KIUC, NREL PVWatts, GTM Research. CT = Combustion turbine, D = Diesel engine, GT = Gas turbine, S = Steam turbine.

# Technologies and Outlook

# Lithium-Ion Chemistries Dominated Grid-Tied Storage Deployments at 97% in Q1 2016

Quarterly Energy Storage Deployment Share by Technology (MW %)



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

Source: GTM Research / ESA U.S. Energy Storage Monitor: Q2 2016

# Commercial Storage Technologies Offer from Few Minutes to Few Hours Capabilities

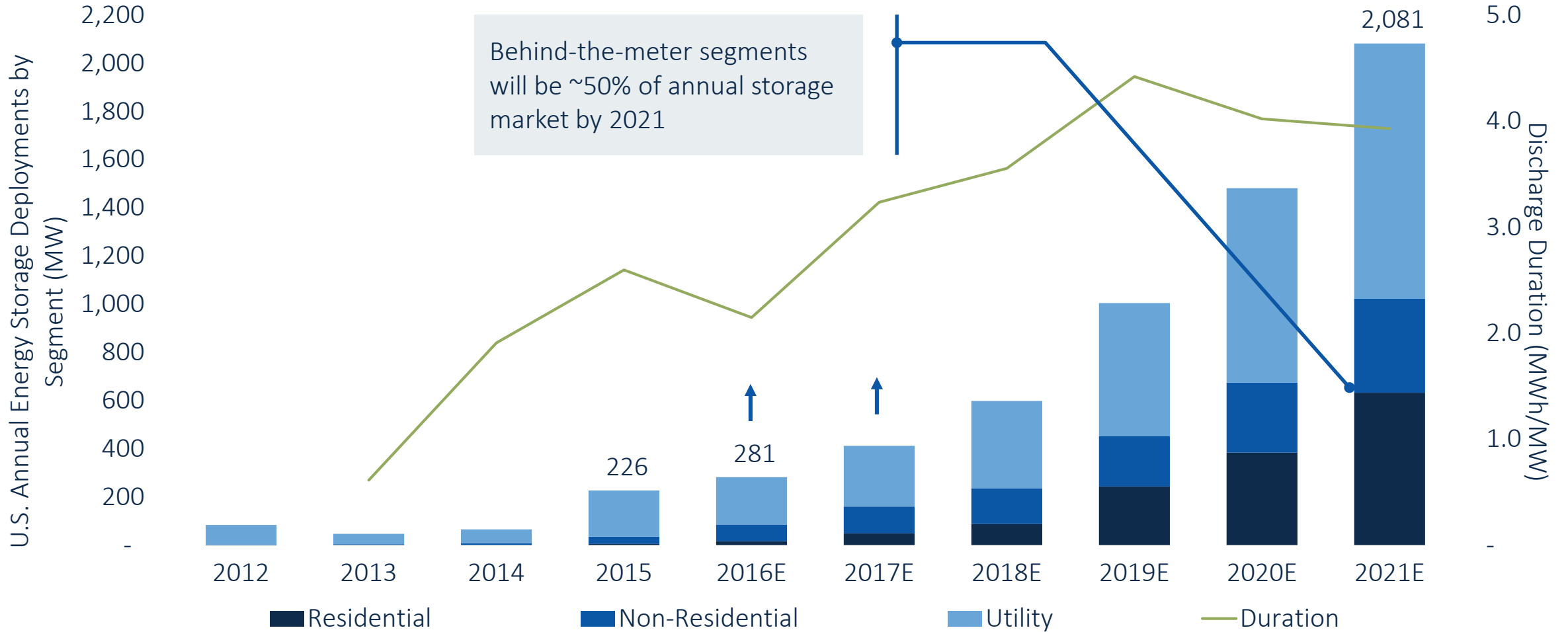
## Storage Technology Comparison – Lithium-Ion, Lead-Acid, Sodium-Based, Flow, Aqueous Liquid Metal, Zinc Hybrid Cathode, Ultracapacitors and Flywheels

Storage Technology	Characteristics	Storage Technology	Characteristics	Storage Technology	Characteristics
Lithium-Ion Batteries	Over 250 MW of utility-side batteries deployed; easiest to site, permit and finance on both sides of meter	Flow Batteries	DC efficiency of 65%-80%; cycle life reaching 10,000-12,000. Generally configured for 4+ hour discharge durations.	Zinc Hybrid-Cathode Batteries	Roundtrip efficiency of 75%; cells demonstrated cycle life of 6,000 in lab. Systems deployed today are rated for 5,000 cycles.
Lead-Acid Batteries	Cycle life ~1,000; no advanced management systems necessary. Advanced technologies can offer up to 5,000 cycles.	Aqueous Batteries	Roughly a lead-acid replacement; nonflammable, non-explosive, nontoxic; DC efficiency reaching greater than 80%; cycle life of 3,000	Ultracapacitor Energy Storage	High power, low energy; cycle life of nearly 1 million and calendar life of up to 20 years
Sodium-Based Batteries	DC efficiency of ~85%; cycle life for sodium-based batteries is 3,500-4,500 and calendar life is 10-15 years	Liquid Metal Batteries	DC efficiency of 80%; cycle life still being tested; capable of millisecond-level response	Flywheel Energy Storage	Roundtrip efficiencies of ~90%; cycle life of 100,000+ and calendar life of up to 20 years; response time of <4 milliseconds

Source: GTM Research / ESA U.S. Energy Storage Monitor: Q2 2016

# U.S. Energy Storage Market Will Exceed the 2 GW Threshold in 2021

## Market to Move to More Medium-to-Long Duration



Source: GTM Research / ESA U.S. Energy Storage Monitor: Q2 2016

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