U.S. Energy Storage Monitor:
Q3 2015 Executive Summary

Prepared For:

gtmresearch

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gtmresearch

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.

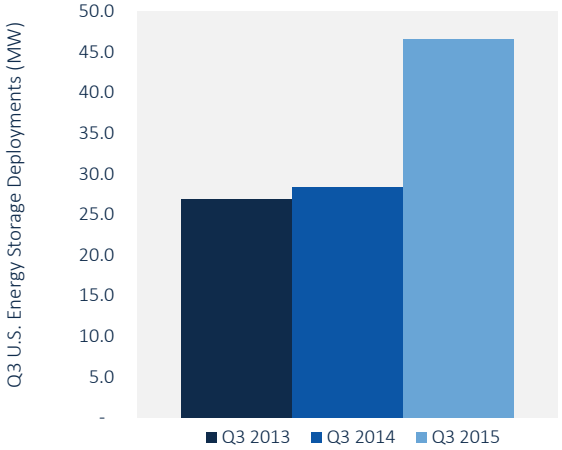
Notes:

- 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 Matt Roberts with the Energy Storage Association (m.roberts@energystorage.org)

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

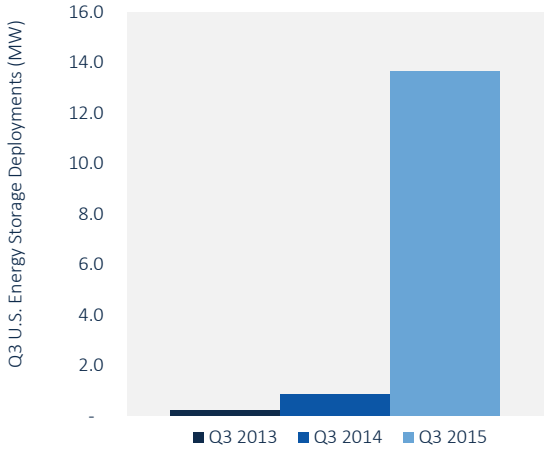
Q3 U.S. Energy Storage Deployments, 2013-2015 (MW)

Front of the Meter



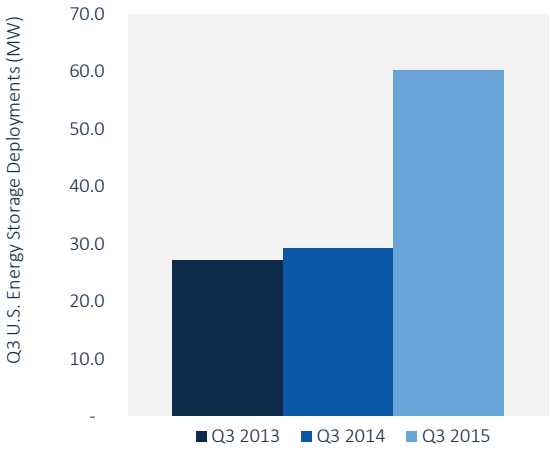
Source: GTM Research

Behind the Meter



Source: GTM Research

Total

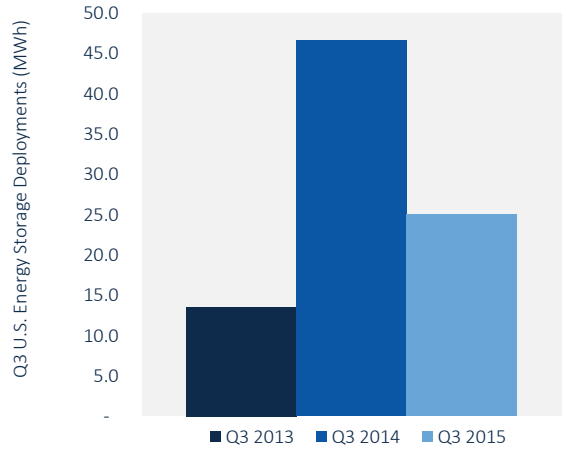


Source: GTM Research

- 60.3 MW of energy storage were deployed in Q3 2015, a twofold increase from Q3 2014 and a 46% increase from Q2 2015
- The behind-the-meter market continued its strong showing of previous quarters, growing over 15 times larger than in the same period last year
- The front-of-the-meter market had its best quarter since Q4 2012 when the 36 MW Notrees project was interconnected

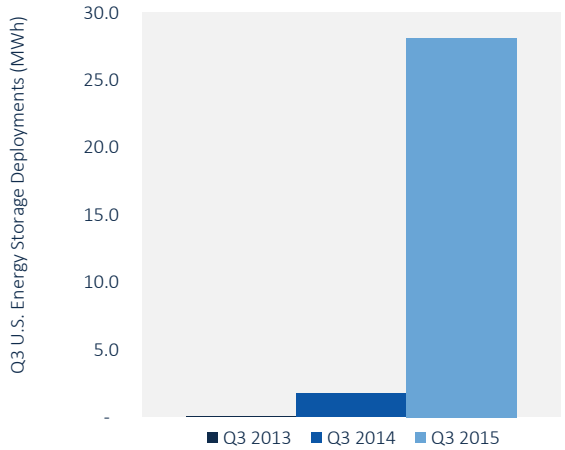
Q3 U.S. Energy Storage Deployments, 2013-2015 (MWh)

Front of the Meter



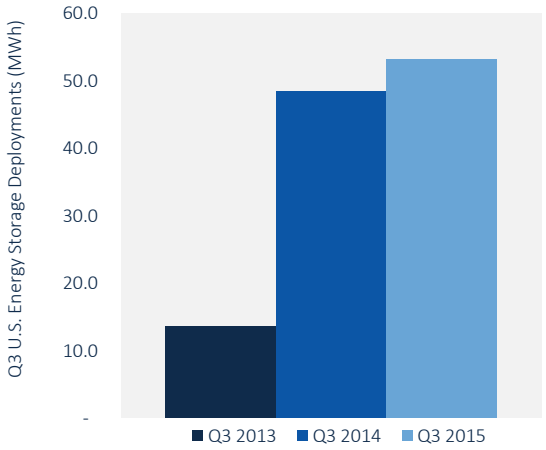
Source: GTM Research

Behind the Meter



Source: GTM Research

Total



Source: GTM Research

- 53.1 MWh of energy storage were deployed in Q3 2015, a 10% increase from Q3 2014 and a fourfold increase from Q3 2013
- The behind-the-meter market continued its strong showing of previous quarters, growing over 16 times larger than in the same period last year
- The utility segment dropped 46% from Q3 2014, as the largest battery-based storage systems in terms of MWhs, the Tehachapi Wind Energy Storage Project (8 MW/32 MWh), was deployed in Q3 2014, while most of the front-of-meter projects in Q3 2015 were short-duration frequency regulation projects in PJM

Top Energy Storage Markets, Q3 2015

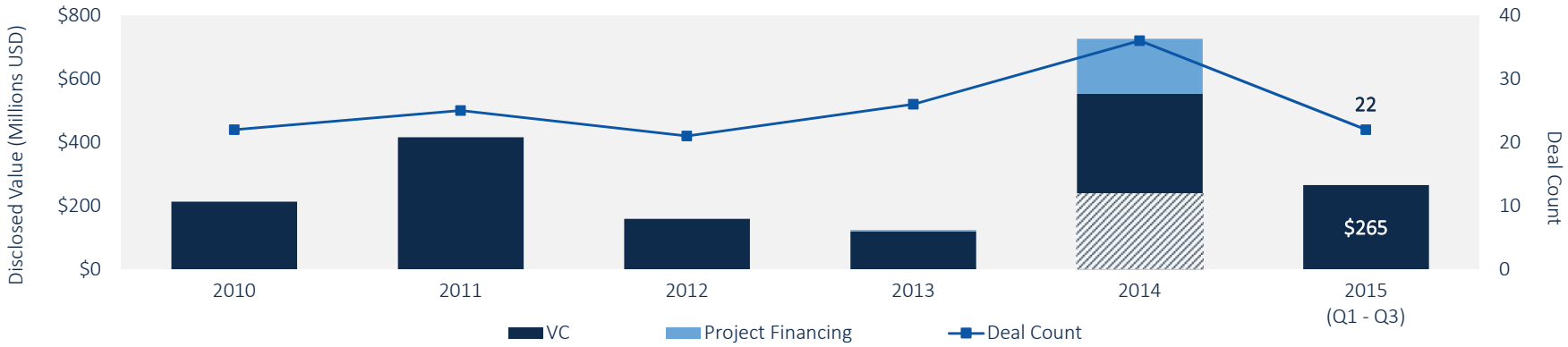
Rank	Residential	Non-Residential	Utility
1	Hawaii	California	PJM (excl. NJ)
2	All Others*	Hawaii	California
3	California	New York	All Others*

Source: GTM Research

- PJM (excl. NJ) was the largest utility-scale market in Q3 2015, followed by California
- California continued to be the largest non-residential market in Q3 2015
- For the first time, Hawaii surpassed California in terms of residential energy storage deployments in Q3 2015

* GTM Research is currently monitoring seven individual markets. Complete coverage of all markets is available in the full report.

Energy Storage Investments Total $265 Million in 2015



Source: GTM Research

- The total disclosed investment in 2014 was boosted by a rumored $250 million investment in Boston-Power (shaded in the figure above)
- Octillion, Sonnenbatterie, Advanced Microgrid Solutions, Stem, Greensmith, Primus Power and SolidEnergy received funding in Q3 2015
  - Stem's $30 million Series C (second tranche) investment and Primus Power's $25 million Series D investment accounted for nearly 70% of investment
  - ČEZ, RWE and AEP joined the list of utility investors in energy storage

Note: 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.

Front-of-the-Meter Policy and Market Developments, Q3 2015

Washington

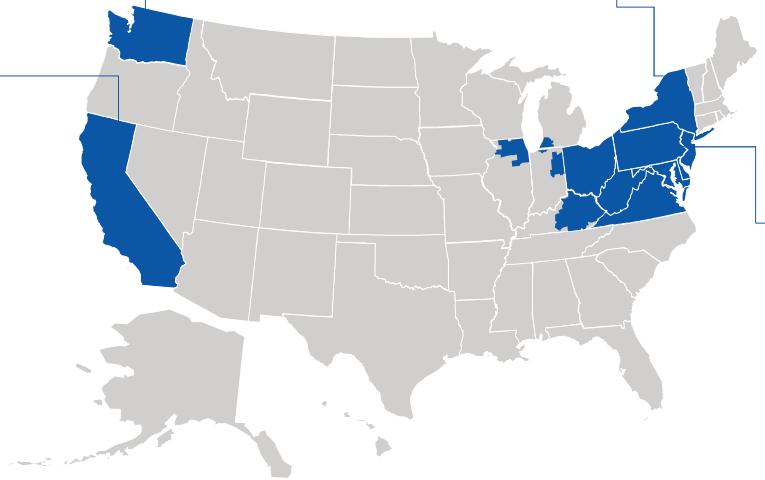
Washington Utilities and Transportation Commission issued a white paper encouraging IOUs to model costs and benefits of energy storage systems for upcoming Integrated Resource Plans

New York

NYSERDA and **Consolidated Edison** jointly released a battery storage safety RFP; **Public Service Commission** ordered utilities to file Distribution System Implementation Plans

California

Legislature passed SB 350 to set a target of 50% renewable electricity by 2030. **CPUC** to provide decision on Track 1 of Calif.'s energy storage procurement framework by December 2015; also partially approved SCE's Local Capacity Requirements RFO with the exception of 7 contracts. **SCE** chose 16.3 MW of resource adequacy storage projects under 2014's RFO; also issued an RFO to solicit of to 100 MW to support the Preferred Resources Pilot. **PG&E** issued an RFO to procure a compressed-air energy storage system. **CAISO** approved DERP framework, and is currently conducting ESDER stakeholder initiative to address rules for participation of storage and other DER assets in ISO markets.



PJM

PJM Operating Committee proposed changes to RegD cap of 40%, down from the previous cap of 62%, and modified the ranking procedure for self-scheduled and $0 cost resources. A Senior Task Force has been created to re-evaluate application of marginal benefit function to regulation market.

Federal

Senate introduced American Energy Innovation Act for purposes of grid modernization. **Department of Treasury** and the **IRS** solicited public comments on ITC to determine if energy storage should qualify. **NASA** selected two energy storage technology proposals under its Game Changing Development Program.

Front-of-the-Meter Policy and Market Developments, Q3 2015 (Cont.)

Oregon

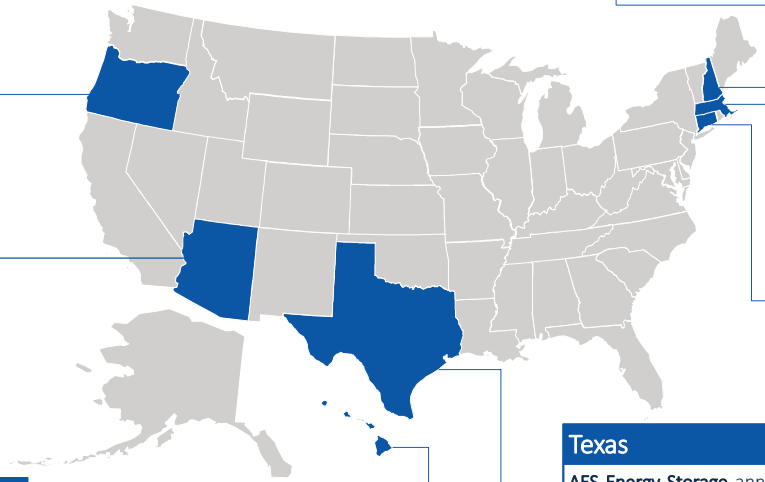
Oregon PUC opened a docket to comply with the state's procurement targets for IOUs; **Oregon DOE** issued an RFP for an energy storage demonstration project with up to $300,000 available to the awardee

New Hampshire

PUC initiated an investigation into grid modernization following an order under the 10-Year State Energy Strategy

Massachusetts

IOUs filed grid modernization plans in August 2015 as directed by **DPU**; **DOER** selected a study partner for its energy storage initiative in September 2015



Arizona

TEP selected two 10 MW storage projects under REST

Connecticut

State legislature amended state budget provisions to require Conn. electric distribution companies to submit pilot proposals for grid-side system enhancements; also passed act to permit the creation of storage RFPs

Hawaii

KIUC entered in a 20-year PPA with **SolarCity** for power from a 13 MW/52 MWh lithium-ion storage system

Texas

AES Energy Storage announced a 20 MW storage project in **Oncor** territory which is expected to come on-line in late 2016; **ERCOT** established the DREAM Task Force to determine protocols and market rules for distributed energy resources

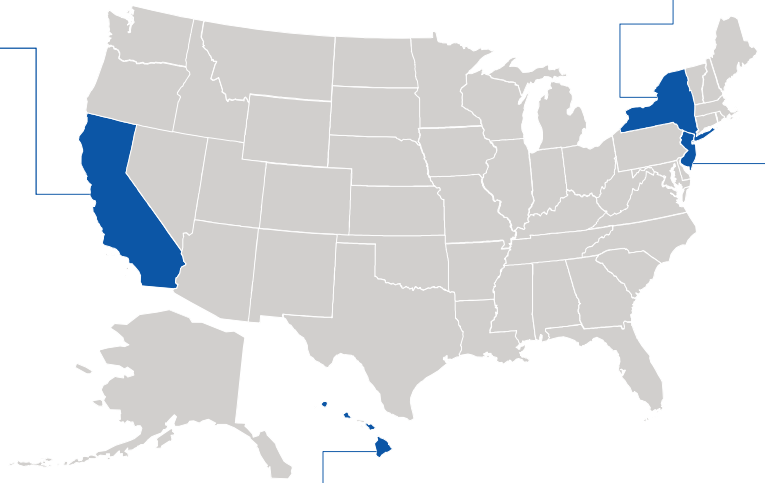
Behind-the-Meter Policy and Market Developments, Q3 2015

California

PG&E and **Olivine** opened supply-side pilot for residential customers. **CPUC** issued the Demand Response Auction Mechanism; modifications to SGIP's GHG emission factor still under consideration. **SCE** issued an RFO to solicit up to 100 MW to support the Preferred Resources Pilot. **SCE, SolarCity** and the **SunSpec Alliance** announced a partnership for the Smart Energy Homes demonstration project. **CAISO** approved DERP framework, and currently conducting ESDER stakeholder initiative to address rules for participation of storage and other DER assets in ISO markets.

New York

NY PSC announced first demonstration projects under NY REV



New Jersey

NJ BPU issued the Second Straw Proposal for the FY 2016 Renewable Electric Storage Incentive Program

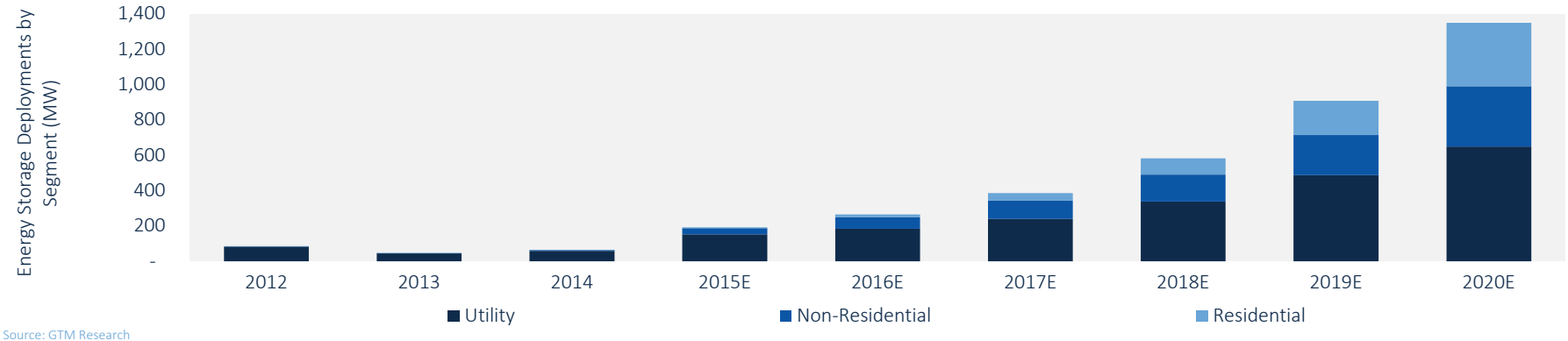
Hawaii

Hawaii PUC ended traditional net metering for new solar customers and instead offered two new options: self-supply or grid-supply

Federal

Department of Treasury and the **IRS** solicited public comments on ITC to determine if energy storage should qualify

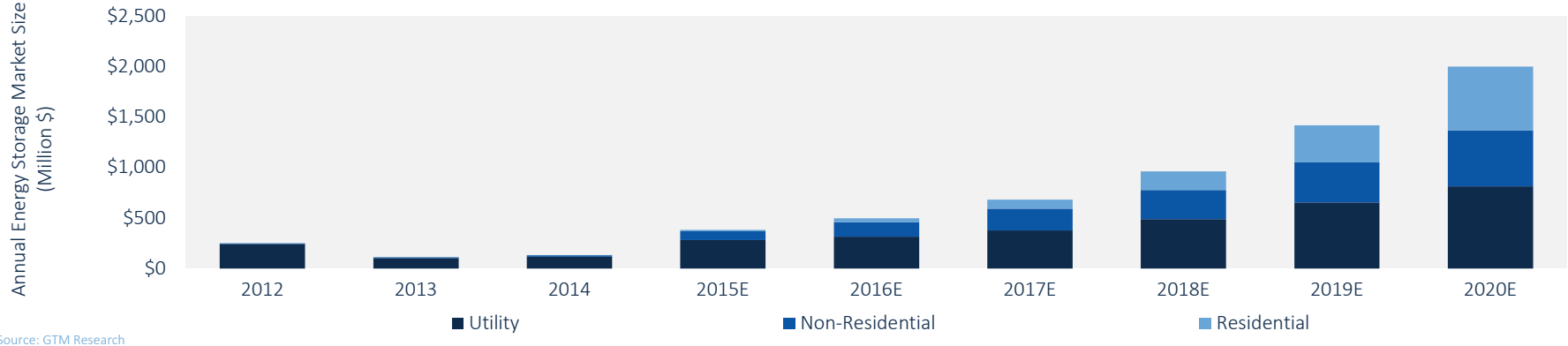
U.S. Annual Energy Storage Deployments Will Surpass 1 GW in 2020



Source: GTM Research

- We expect significant growth in the U.S. energy storage market over the next five years across all sectors, resulting in an 1,349 MW annual market in 2020 – 21 times the size of the 2014 market, and seven times the size of 2015 market
- 2015 will see particularly rapid growth, with 192 MW deployed and each segment more than doubling on an annual basis, with a further upside in the nonresidential segment

U.S. Energy Storage Market to Reach $2 Billion by 2020



Source: GTM Research

- The U.S. energy storage market will grow from $134 million in 2014 to $381 million in 2015 (up 184%)
- By 2020, the U.S. energy storage market will be $2 billion, a fifteenfold increase from 2014 and a fivefold increase from 2015
- The behind-the-meter sector is expected to surpass the utility sector in 2019, and continue the faster adoption to reach 59% of total market in 2020

Energy Storage and Clean Power Plan: Case Study #1

California Self-Generation Incentive Program Greenhouse Gas Emission Factor Determination

SGIP: Proposed GHG Emission Factor and Round-Trip Efficiency Revisions

In July 2015, the California Public Utilities Commission (CPUC) issued a proposal to raise the greenhouse gas (GHG) emission factor required for technologies applying for incentives under California's Self-Generation Incentive Program (SGIP). Under the proposal, the emissions factor is reduced from 379 kgCO2/MWh to 360 kgCO2/MWh, while the minimum round-trip efficiency for energy storage projects is increased from 63.5% to 66.5% to meet the new emission target. The final decision was made on November 19, 2015. Details on the final decision will be discussed in U.S. Energy Storage Monitor: 2015 Year-in-Review.

Energy storage systems, as net consumers of electricity, increase total load. Storage, however, possesses the ability to shift load from peak to off-peak hours, and thus reduce the utilization of less efficient peaker plants. Therefore, it is necessary to consider the GHG emission factors of both the off-peak resources the storage systems charge from, as well as the peak resources they displace when discharging.

In order to meet SGIP's GHG requirements, systems' averaged 10-year emissions must be less than the mandated emissions factor (assuming performance degradation of 1%/year); "for AES [advanced energy storage] systems, this determination is made for specific model types and then applied to all applications with those model types."* SGIP assumes AES systems charge during off-peak hours and discharge during peak hours; net emission impact for avoided peak-hour emissions is based on the emission rate of new combustion turbines, while the off-peak marginal emission rate is based on the emission rate of a new combined-cycle gas turbine.

*Source: CPUC

SGIP: Proposed GHG Emission Factor and Round-Trip Efficiency Revisions – Calculations

GHG Emission Factor Equation:

GHG EF = (0.5(EROLF * (1 - WFP) + EROP* WFP) + 0.5 * (1-RPS% * (1 - LLF)) * (ERBLF* (1 – WFP) + ERBP * WFP))/(1 – LLF)

Where:

GHG EF = Greenhouse gas emission factor

EROLF = Operating margin emission rate of load-following plants = 382 kgCO2/MWh

WFP = Weighting factor for peaker plants = 8%

EROP = Operating margin emission rate of peaking plants = 544 kgCO2/MWh

RPS% = RPS portfolio requirement = 33%

ERBLF = Build margin emission rate of load-following plants = 368 kgCO2/MWh

ERBP = Build margin emission rate of peaking plants = 524 kgCO2/MWh

LLF = Line loss factor = 8.4%

Degradation rate = 1%/year

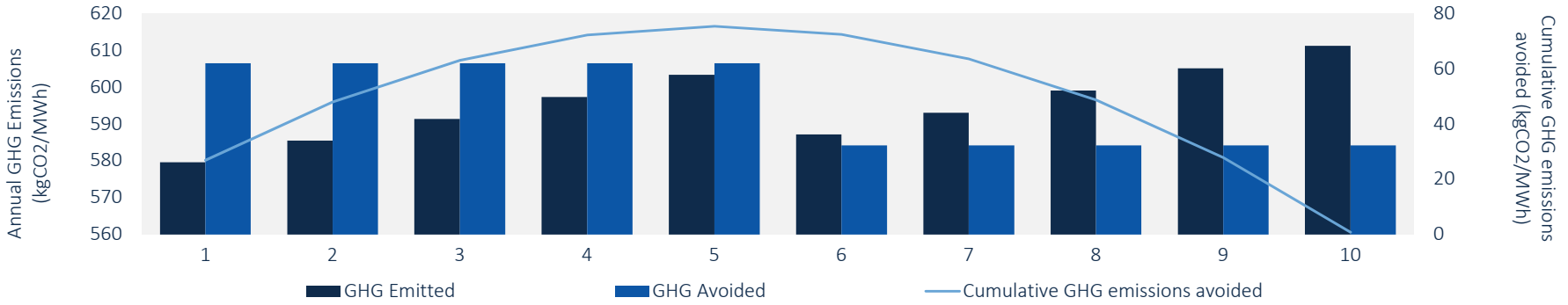
Result

GHG EF = 360 kgCO2/MWh

*Source: CPUC

SGIP: Proposed GHG Emission Factor and Round-Trip Efficiency Revisions – Minimum Efficiency of 66.5% For Net Zero GHG Emission Reduction

Energy Storage Round-Trip Efficiency Calculation Results*

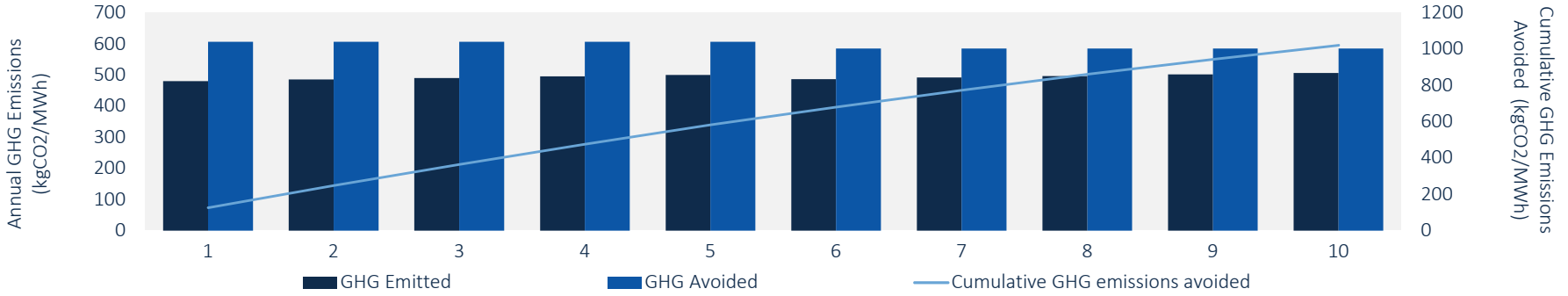


*Source: GTM Research

The above scenario yields a 10 year average round-trip efficiency of 66.5% (first year round-trip efficiency of 69.6%) assuming an off-peak line loss factor of 5.3%, an on-peak line loss factor of 10.3%, and a performance degradation rate of 1%/year. The Off-Peak Emission Rate is based on a combined-cycle gas turbine; the on-peak emission rate is based on a simple cycle combustion turbine in the near term. Over the long term (years 6-10), the CPUC assumes that SGIP assets will offset new generation capacity, which will include renewable energy generation technologies. As a result, the avoided and emitted GHG emissions from years 6-10 are visibly lower than years 1-5. With these parameters, a storage system with average round-trip efficiency of 66.5% emits net-zero GHGs over 10 years.

SGIP: Average Round-Trip Efficiency of 80.3% Will Result in 17% GHG Emissions Reduction Over 10 Years Using CPUC Framework

Energy Storage Round-Trip Efficiency: 84% Initial Efficiency Case



*Source: GTM Research

Assuming a starting round-trip efficiency of 84%, which is seen today in many available lithium-ion energy storage systems, and keeping all other parameters the same as the previous case, GTM Research analyzed a scenario where positive emission reductions could be achieved. In this case, the average 10-year round-trip efficiency is 80.3% and there is a cumulative GHG emissions avoidance of 1,021 kgCO2/MWh over the 10-year timeframe, that equates to 17% GHG emission reduction. In the context of the Clean Power Plan, 17% GHG reduction by deploying customer-sited energy storage systems is non-trivial.

SGIP: Proposed GHG Emission Factor and Role of Energy Storage

Energy storage systems will reduce emissions below the proposed 360 kgCO2/MWh threshold, assuming a round-trip efficiency of 66.5% or greater. The calculation methodology utilized by CPUC assumes storage systems' emissions rate is equal to that of a new combined cycle gas turbine (i.e., 382 kgCO2/MWh) and that the energy discharged displaces energy generated by a new simple-cycle combustion turbine (i.e., 544 kgCO2/MWh). GHG emission factors become significantly lower if storage charges from renewable resources; as more renewables are brought on-line, it will be important to consider their effect on the GHG emission factor of energy storage systems. We examine the impact of combining energy storage with renewables on GHG emissions in the Kauai Island Utility Cooperative-SolarCity case study (available in the full report).

If passed in its current form, this policy will require higher energy storage system round-trip efficiency within California and encourage further technology development, as the state currently possesses the largest behind-the-meter energy storage market in the U.S. California recently passed SB 350, which instituted a target of 50% for the state's renewable electricity mix by the end of 2030 (increasing from the previous target of 33% by the end of 2020), along with a commitment to reduce GHG emissions to 1990 levels by 2020. Therefore, the proposed emissions and efficiency thresholds are likely to help achieve the state's aggressive environmental goals. Furthermore, a more stringent GHG emissions factor will limit what technologies are eligible for SGIP, and may result in greater deployments of energy storage technologies, as fewer incentives would be available for gas turbines. At present, it is unclear if the proposal will pass.

This case study offers a glimpse into the treatment of energy storage in GHG emission-reduction conversations, when used to displace simple-cycle gas turbines. Companies such as GE have hinted at gas-turbine-plus-storage products that improve turbine operations and lower GHG emissions.

For more information on GTM Research resources, including additional coverage of the U.S. Energy Storage Market, please contact **sales@gtmresearch.com**.

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