Energy Storage at the Frontier of Distribution System Planning

Jason Burwen
Vice President, policy

NASEO Energy Policy Outlook Conference
February 4, 2020

Energy Storage Association

Our Members

- manufacturers
- component suppliers
- system integrators
- developers
- independent generators
- electric utilities
- large end-users
- law, finance, consulting

Technologies represented

- battery storage
- thermal storage
- mechanical storage
- power-to-gas storage

ESA Energy Storage Association

U.S. grid battery storage now past the 1 GW mark

Battery Storage MW Operational and in Development, Dec 2018

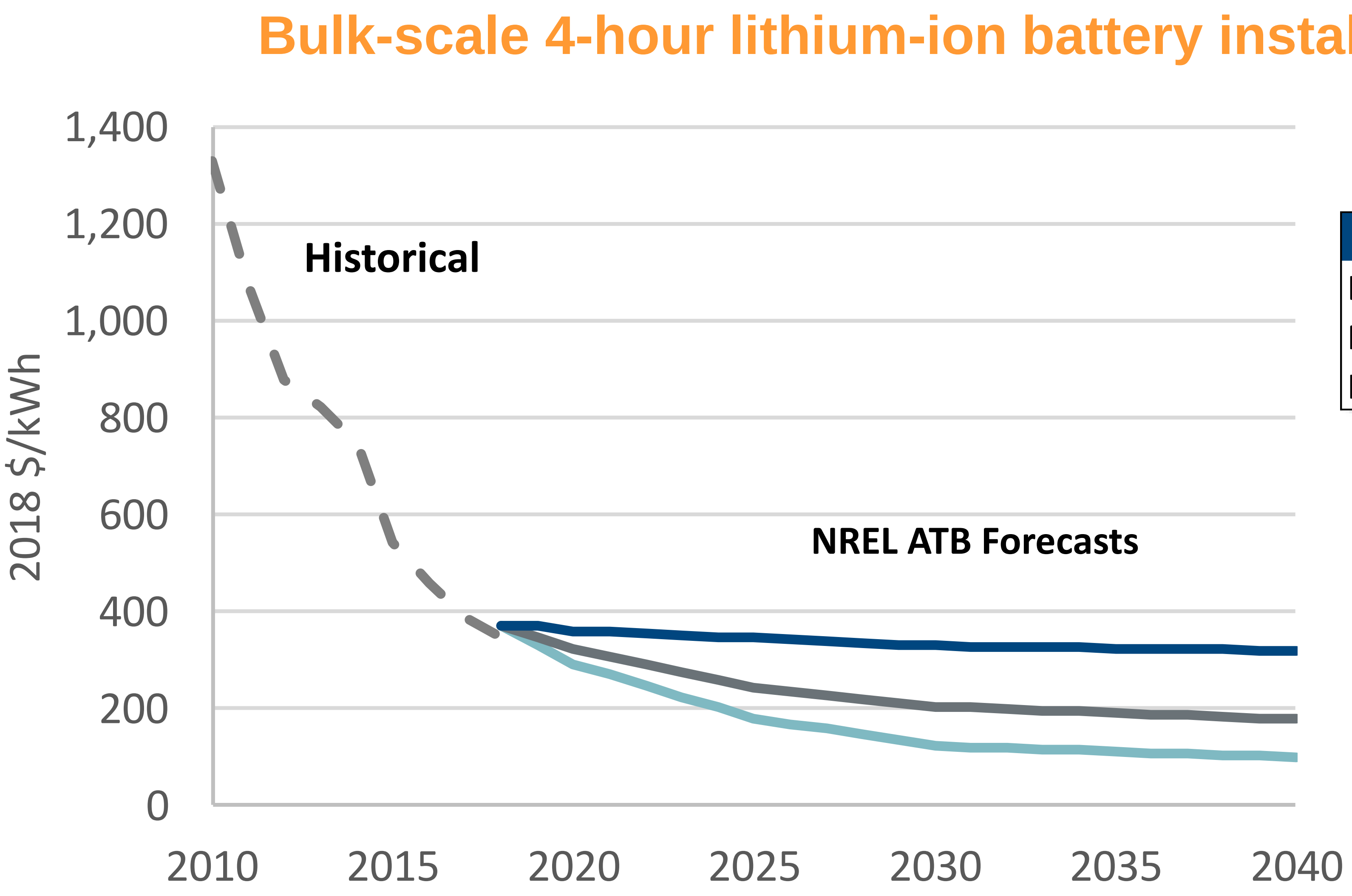
As of 2Q 2019:

1.3 GW (2.3 GWh) batteries online

35% of MW installed “behind-the-meter”

(SOURCE: WoodMackenzie)

Battery storage installed costs continue to drop



Annual Cost Decline Rates from 2018

	2025	2030	2040
Low Cost	-10%	-9%	-6%
Mid Cost	-6%	-5%	-3%
High Cost	-1%	-1%	-1%

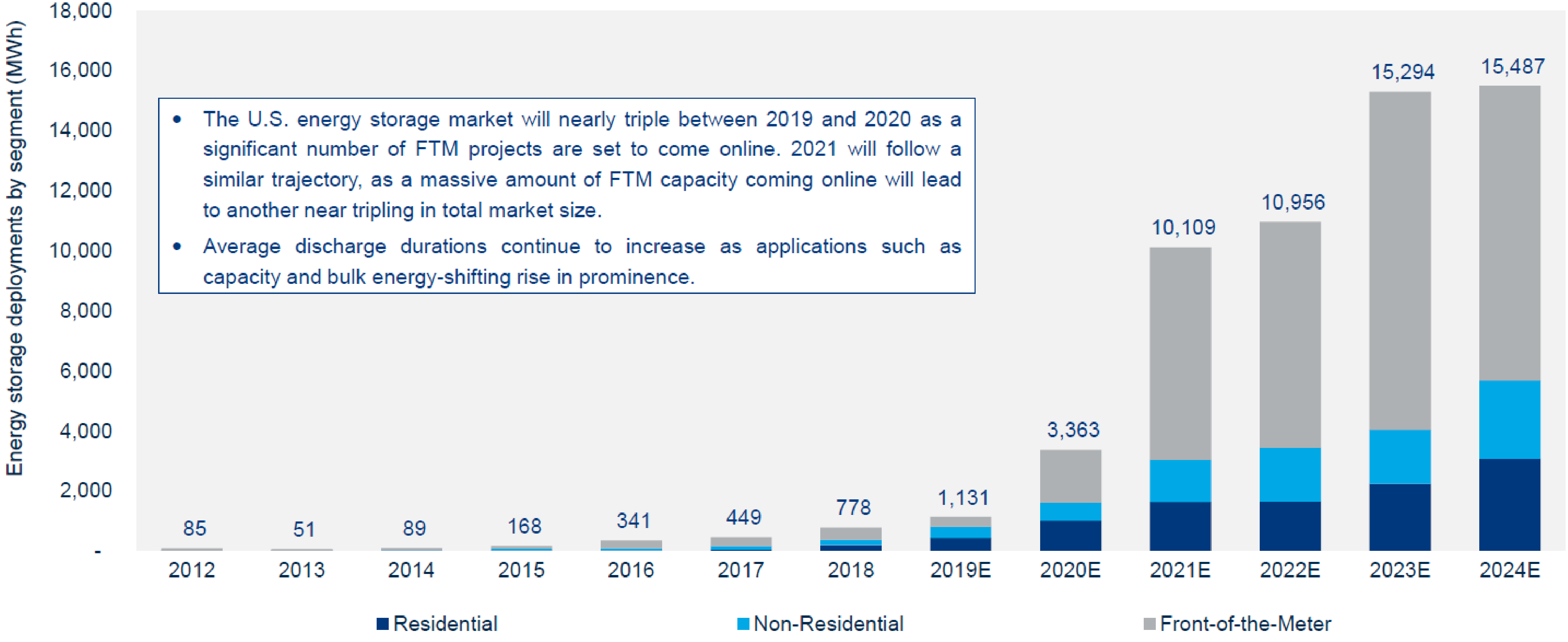
Source: Bloomberg New Energy Finance (2018) and NREL (2019b) with Brattle analysis.

Notes: Historical estimate assumes Bloomberg NEF battery pack cost estimate plus a constant non-pack cost estimate of approximately $170/kWh. NREL costs are for a 4-hour, utility-scale lithium ion battery.

U.S. market will reach 15.5 GWh in annual deployments by 2024

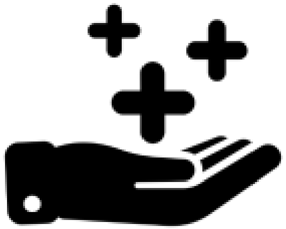
4-hour systems becoming the norm for front-of-the-meter systems; average BTM durations inch toward 3 hours

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



- The U.S. energy storage market will nearly triple between 2019 and 2020 as a significant number of FTM projects are set to come online. 2021 will follow a similar trajectory, as a massive amount of FTM capacity coming online will lead to another near tripling in total market size.
- Average discharge durations continue to increase as applications such as capacity and bulk energy-shifting rise in prominence.

Barriers to Deployment That Policy Can Address



Cannot VALUE or compensate storage flexibility

Solutions

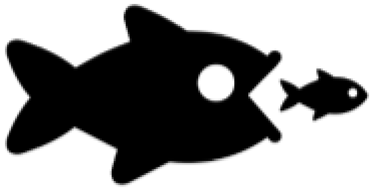
Deployment targets

Incentive programs

Tariff/rate design

Wholesale market products

Cost-benefit studies



Unable to COMPETE in all grid planning and procurements

Solutions

Long-term resource planning

Distribution planning

Transmission planning

GHG/renewables standards

Wholesale market rules

Resource adequacy rules

Cannot ACCESS grid or constrained to narrow use

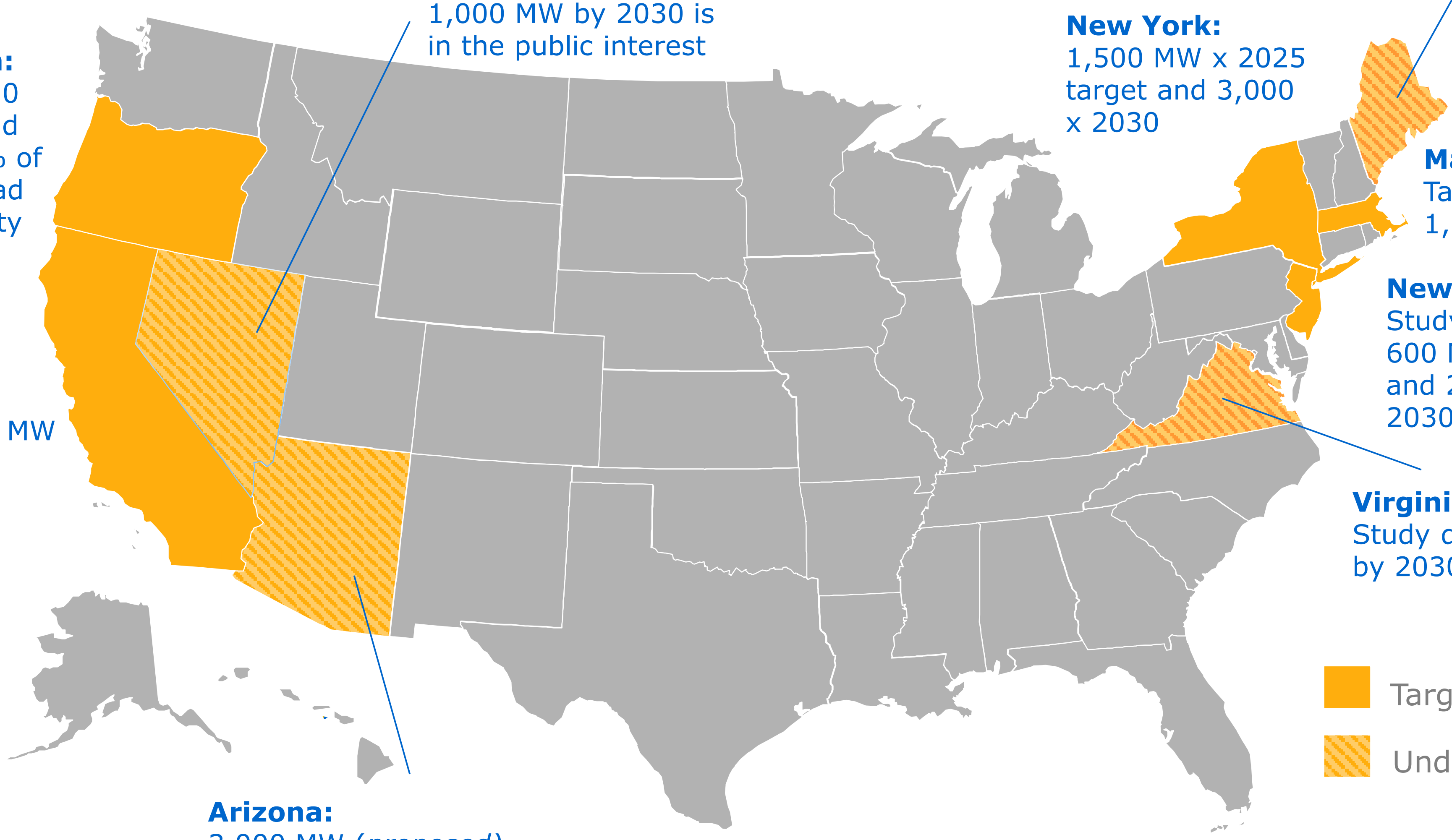
Solutions

Interconnection processes

Multiple-use frameworks

Ownership rules

Storage Targets/Goals



Nevada:
Study determined 1,000 MW by 2030 is in the public interest

Maine:
100 MW *(proposed)*

New York:
1,500 MW x 2025 target and 3,000 x 2030

Oregon:
Min of 10 MWh and max 1% of peak load per utility

Massachusetts:
Target of 1,000 MWh x 2025

New Jersey:
Study plus 600 MW x 2021 and 2,000 MW x 2030 *goal*

California:
1,325 MW x 2020 + extra 500 MW

Virginia:
Study determined 1,000 MW by 2030 as economic

Arizona:
3,000 MW *(proposed)*

Target/goal in place

Under development

Storage Incentives

Nevada:
$10MM solar+storage program

New York:
Bridge Incentive Program ($280MM) + NY-Sun program ($40MM)

Massachusetts:
SMART incentive program for solar+storage; Clean Peak Standard program in development

California:
Self-Generation Incentive Program ($800MM)

Maryland:
Onsite storage tax credit ($3MM)

Federal: Storage paired with solar eligible for 30% investment tax credit

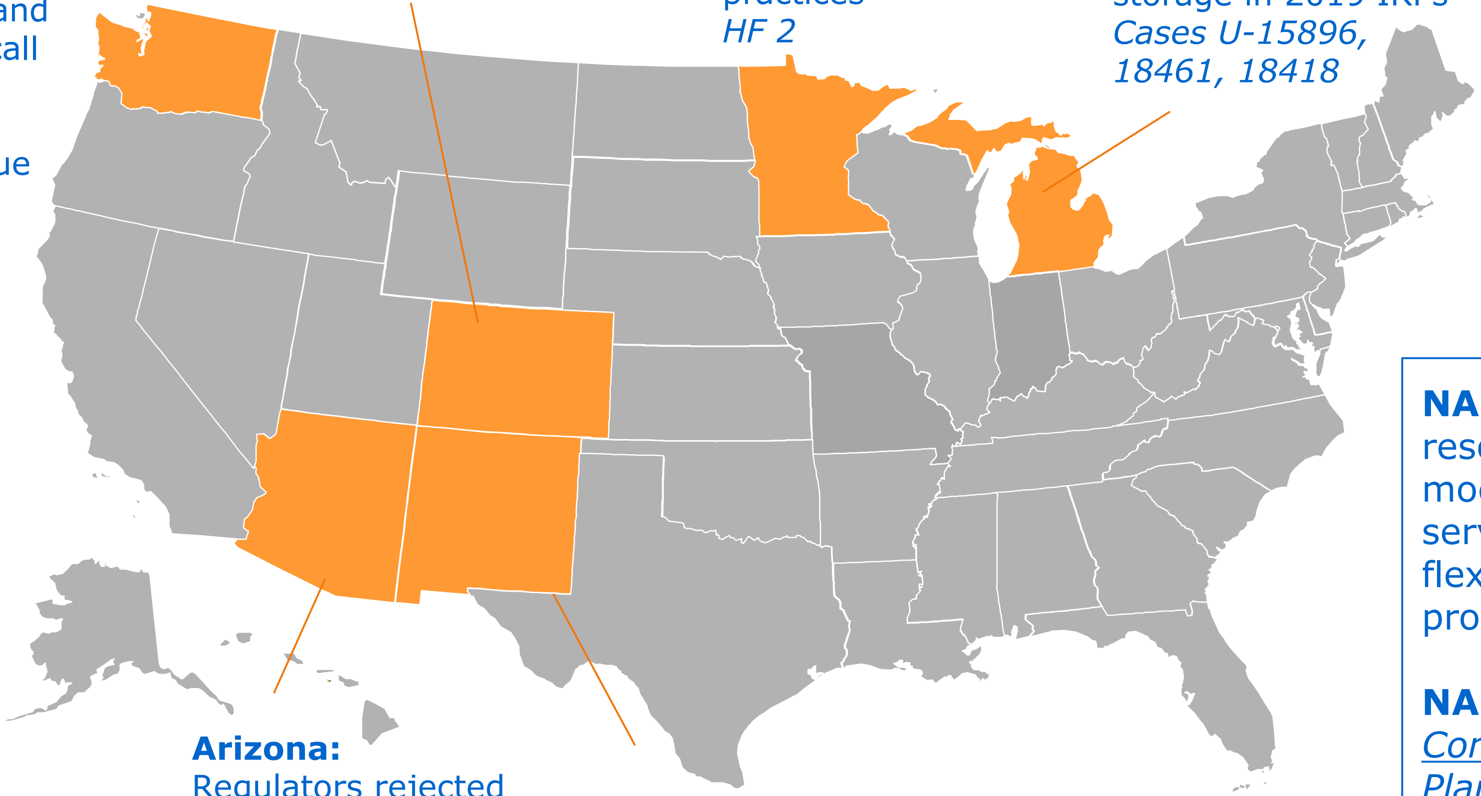
Updating Planning for Storage

Colorado:
PUC updated all planning rules to consider storage procurement
Docket 18R-0623E, Decision C18-1124

Minnesota:
Legislation requires IRPs to include storage modeling best practices
HF 2

Michigan: PSC issued guidelines on consideration of storage in 2019 IRPs
Cases U-15896, 18461, 18418

Washington:
Policy Statement and draft regulations call for sub-hourly modeling and mechanism to value flexibility
Docket U-161024



32 states have planning requirements

Over **7,000 MW** selected to date

Arizona:
Regulators rejected utility IRPs, called for evaluation of storage, gas moratorium
Case E-00000V-15-0094, Decision 76632

New Mexico:
Revised IRP rules require consideration of energy storage
Case 17-00022-UT

NARUC: A November 2018 resolution (EL-4/ERE-1) calls for modeling "the full spectrum of services that energy storage and flexible resources are capable of providing."

NARUC/NASEO: *Task Force for Comprehensive Electricity Planning* is a two-year project, working with 16 states on improving electric system modeling and planning methods

Storage enhances T&D capabilities

- Extend the life of existing electric infrastructure
- Enhance resilience of network & other critical infrastructures
- Increase hosting capacity to enable customer choice
- Adapt to uncertain futures: supply mix, load & DER forecasts
- Enable the demands of increasingly electrified economy
  - Transportation
  - Industrial processes
  - Ubiquitous computing/IoT
  - Heating? Desalination?

Examples of storage as electric infrastructure

- **APS (Arizona) projects**
  - 4 MW storage avoids transmission upgrade for rural communities (Punkin Center)
  - 2 MW storage at 2 substations to increase hosting capacity for customer solar
- **HECO (Hawaii) Aggregation**
  - 1 MW aggregation of customer-sited storage providing distribution system stability
- **National Grid (New York) Nantucket project**
  - 6 MW, 8-hr storage to avoid new undersea cable & island resilience
- **Eversource (New Hampshire) "bring-your-own-device" project**
  - Combination 1.7 MW substation battery + 0.7 MW customer peak demand reduction to avoid distribution upgrades
- **Duke Indiana projects**
  - 5 MW storage at 2 sites in development
    - Grid infrastructure deferral (Naab Battery Project – distribution sited)
    - Resilience (Camp Atterbury Project – customer-sited microgrid)

Benefit-cost analysis of DER storage in planning

- **Traditional benefit-cost analysis examines storage as a wire—e.g., comparing a smartphone to a landline**
  - Value side of the ledger remarkably expanded—e.g., not just the cost of making a phone call
- **Hosting capacity value enhancement**
  - Reduce interconnection burden for customers installing DERs
  - Contribute system-wide services when needed
  - Helps state meet public policy goals
- **Option value**
  - Storage can be quickly deployed in increments to meet reliability needs as they occur and change → manage risk of locking in unnecessary infrastructure capex
  - Storage can be re-deployed if conditions change to obviate reliability need → lower risk of stranded investment
- **Resilience value**
  - Either substation-sited or customer-sited

ESA recommends the Maryland PC 44 Storage Working Group proposal filed at MD PSC

Storage as resilience: an increasing trend

Options for moving toward a grid services market

- **Utility programs can provide payments to storage (+ other DERs) to provide useful services, akin to a price signal**
  - Utility "bring-your-own-device" programs provide payment in exchange for turning over dispatch control under certain conditions (e.g., GMP, Liberty, Eversource BYOD programs)
  - Daily / Targeted Dispatch program in Massachusetts provides payments for storage producing specific dispatch
  - Payments for certain DER functionality (e.g., ComEd $/kVAR incentive for enabling Volt-VAR support) or peak demand reductions
- **RTO/ISO markets define specific services, which are then bid to establish clearing prices**
  - Energy, ancillary services, and sometimes capacity services are defined discretely with price that changes with supply/demand and market conditions
- **Value of DER (VDER) approaches as a partway step to market pricing**
  - Administrative ease of utility program + proxy for market prices
  - Since value is long-term avoided costs, contract length should be set similar to utility asset lifetimes (e.g., 10 years)

conEdison

Components and Eligibility for the VDER Value Stack Phase Two

Overall eligibility: On-site DG >750 kW; Remote Net Metered and Community DG of any size; excludes CHP

Effective 06/01/2019 for projects that qualified[1] for Value Stack after 07/26/2018

		Definition	Description	Units	Eligibility
Supply	**LBMP**	Location Based Marginal Pricing	Energy volumetric credit Day ahead LBMP	$/MWh	All Value Stack-eligible projects
	ICAP - Alt 1	Installed Capacity	Volumetric credit applied to production in all hours, equivalent to the value of avoided capacity levelized over expected PV production	$/kWh	All intermittent resources [2]
	ICAP - Alt 2		Volumetric credit concentrated during 240 or 245 weekday non-holiday summer afternoon hours, from 2 PM until 7 PM June 24 through August 31	$/kWh for 240 or 245 summer hours	All intermittent resources
	ICAP - Alt 3		Volumetric credit based on exports of power coincident with prior summer NYCA peak load	$/kW-month coincident prior summer peak	Required for dispatchable resources [3] Optional for intermittent resources
	REC	Renewable Energy Credit	Environmental Credit Higher of NYSERDA REC price or Social Cost of Carbon	$/kWh	Solar PV, Fuel Cell, Hydro, Wind, Tidal, Biomass [4]
Distribution	**DRV**	Demand Reduction Value	Proxy for distribution value of DER based on avoided Marginal Cost of Service (MCOS) Available for export in 4 hour window during summer non-holiday weekdays between June 24 and September 15. Window assigned during interconnection.	$/kWh	All Value Stack-eligible projects
	CC	Community Credit	Designed to incentivize Community Distributed Generation	$/kWh	Community DG Satellite accounts Solar PV, Fuel Cell, micro-Hydroelectric, and Wind
	LSRV	Locational System Relief Value	Incentive for high value areas based on “stretch” of MCOS. Credited for minimum average hourly export during each event.	$/kW-event	For customers in high value areas, as long as MW Cap has not been reached

[1] Qualification based on date of payment of at least 25% of interconnection costs, or date of executed interconnection agreement if payment is not required
[2] Intermittent resources include: Solar (Photovoltaic), Wind, and Micro-hydroelectric
[3] Dispatchable resources include: Farm Waste Generation, Biomass, Tidal Power, Fuel Cells, Micro-CHP, and Paired Energy Storage
[4] Eligibility for RECs for Biomass generation depends on the fuel source – please see NYSERDA guidelines

Thank you.

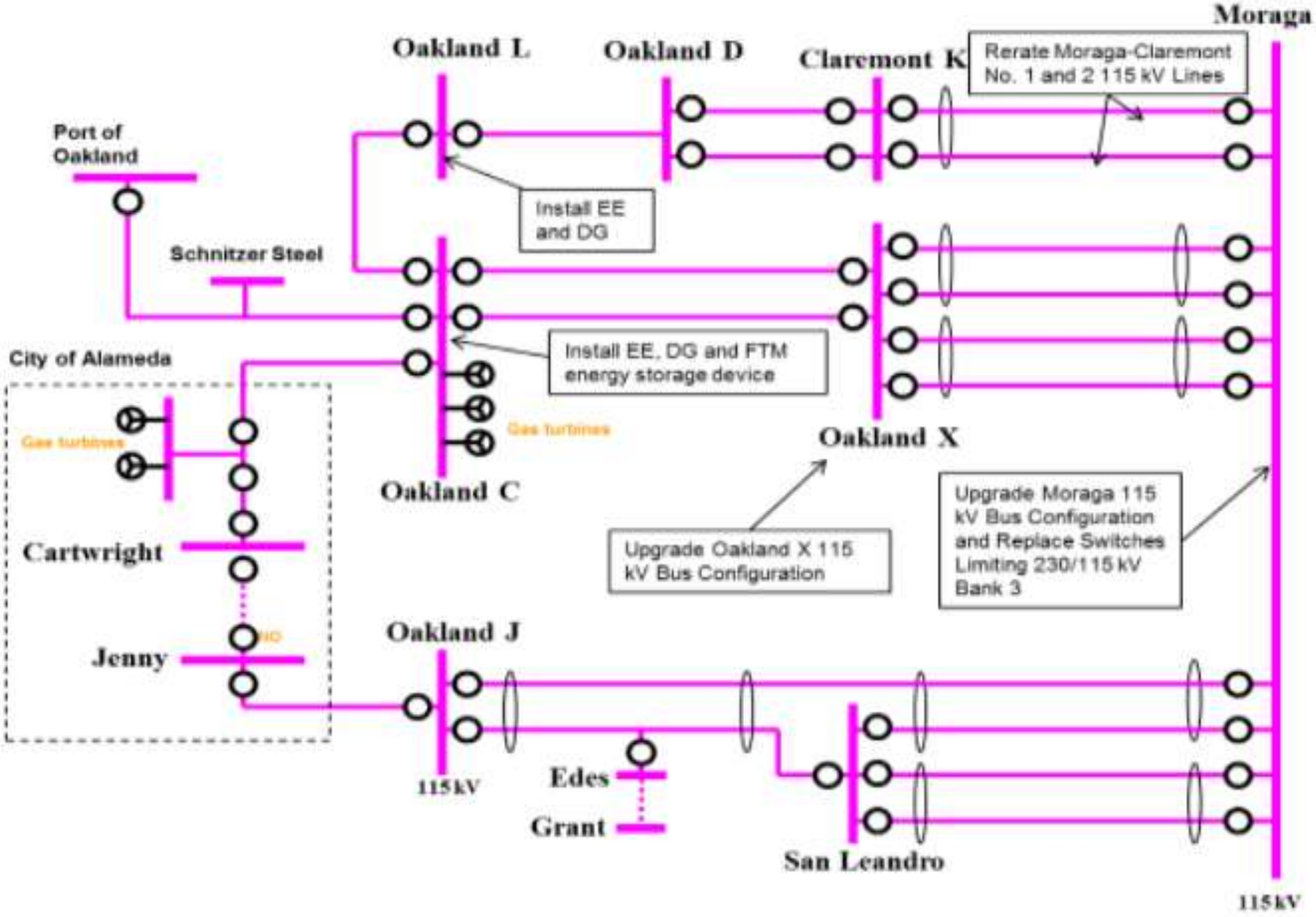
Jason Burwen
j.burwen@energystorage.org

www.energystorage.org

Parking Lot

Example: Oakland Clean Energy Initiative

- **Mix of substation storage and customer DERs used to address thermal overload risk**
  - Allows retirement of aging gas generation used for local reliability
- **Found to be 15-25% of cost of traditional transmission solutions**

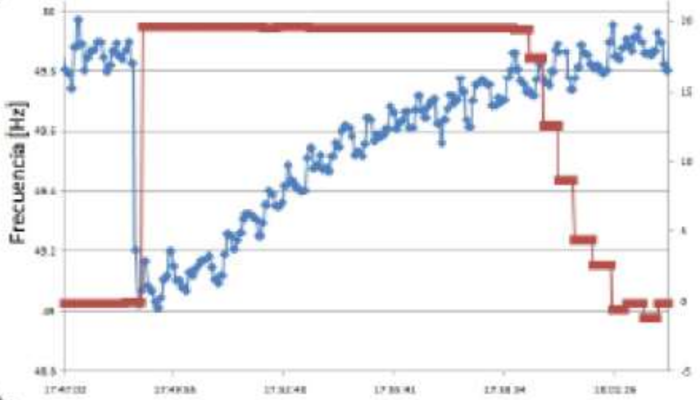


Battery storage for grid stability: Voltage support

- **EPRI 2012 study found batteries superior to SVC/STATCOM for voltage support in N-1 contingency with high dynamic loads**
  - Faster replacement of active and reactive power injection
  - Including active power allows wider area of support
    - SVC only injects reactive power → still requires active power from remote sources thru weak transmission system, increasing stress conditions
    - SVC/STATCOM must be oversized relative to batteries in terms of MVA ratings
  - Efficiency of SVC declines with severe voltage dip
  - Batteries can sustain MW and Mvar injection for longer periods of time for voltage or overload issues in steady-state post-fault operating state
- **Example: APS 2 MW / 2 MWh batteries on distribution feeders being used for voltage regulation, in addition to capacity deferral**
  - Full 2 MVA capacity available for reactive power during peak shaving

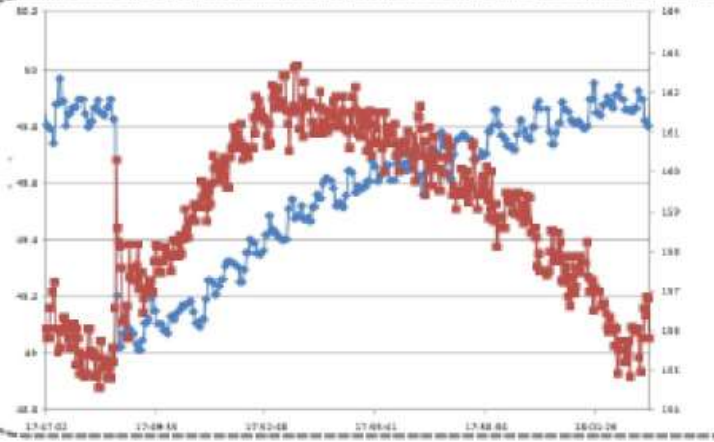
Battery storage for grid stability: Fast frequency response

- **Batteries provide sub-second response at full output (“synthetic inertia”)**
  - Arrests frequency deviations faster → avoids lower nadir → reduces headroom reservations needed for primary frequency response
- **Batteries provide sub-minute response at full output (“primary frequency response”)**
  - Supports faster recovery → reduces headroom reservation for existing generators
- **UK Everoze study finds 360 MW batteries replaces inertia of 3,000 MW of CCGTs**
- **Value of <u>fast</u> frequency response increases as inertia decreases from greater wind/solar deployment**
  - ERCOT, UK have fast frequency response market products



Angamos BESS Response

- ✓ Angamos BESS responds with rapid increase of output from 0MW to 20MW
- ✓ Autonomous response according to programmed profile
- ✓ Output sustained until stability restored



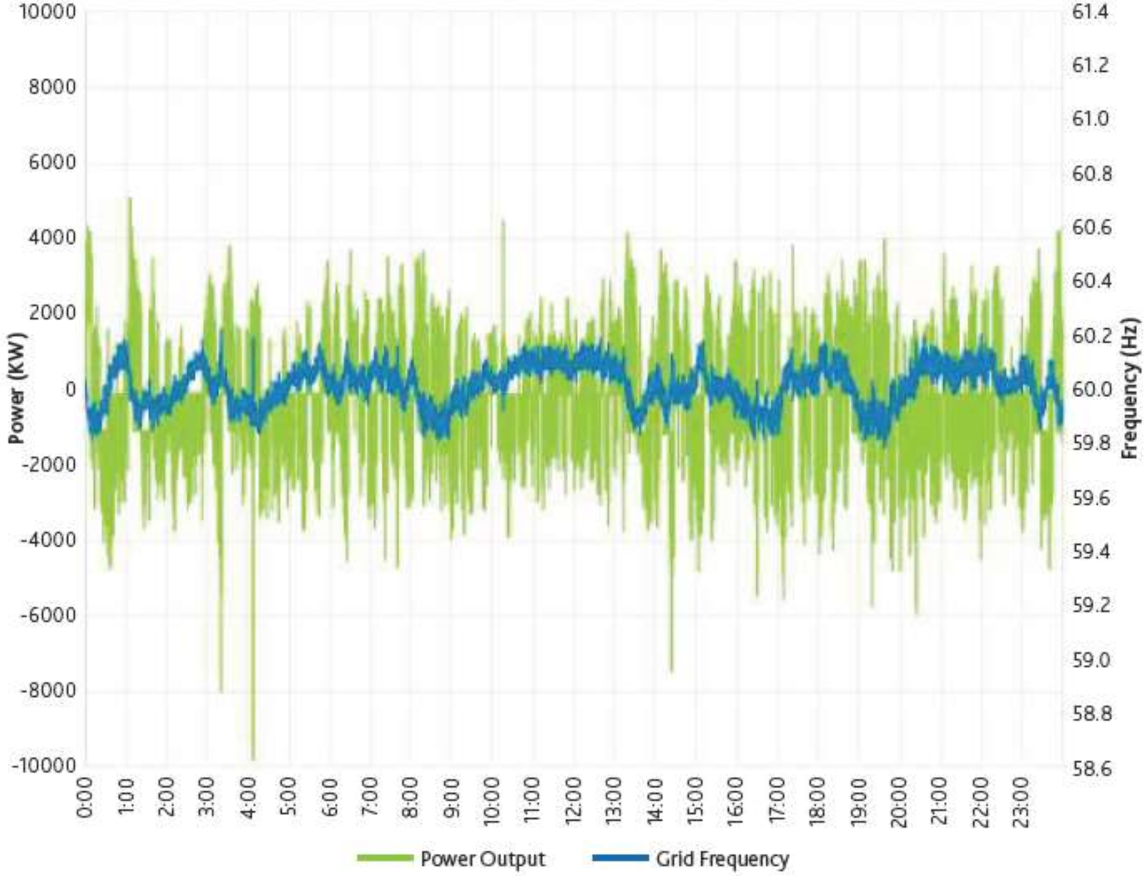
Thermal Units

- ❖ Thermal unit responds with 4MW burst, then output drops off
- ❖ Gradually ramps up in oscillating manner to 7MW output increase over 4 minutes

Fast frequency response as resilience

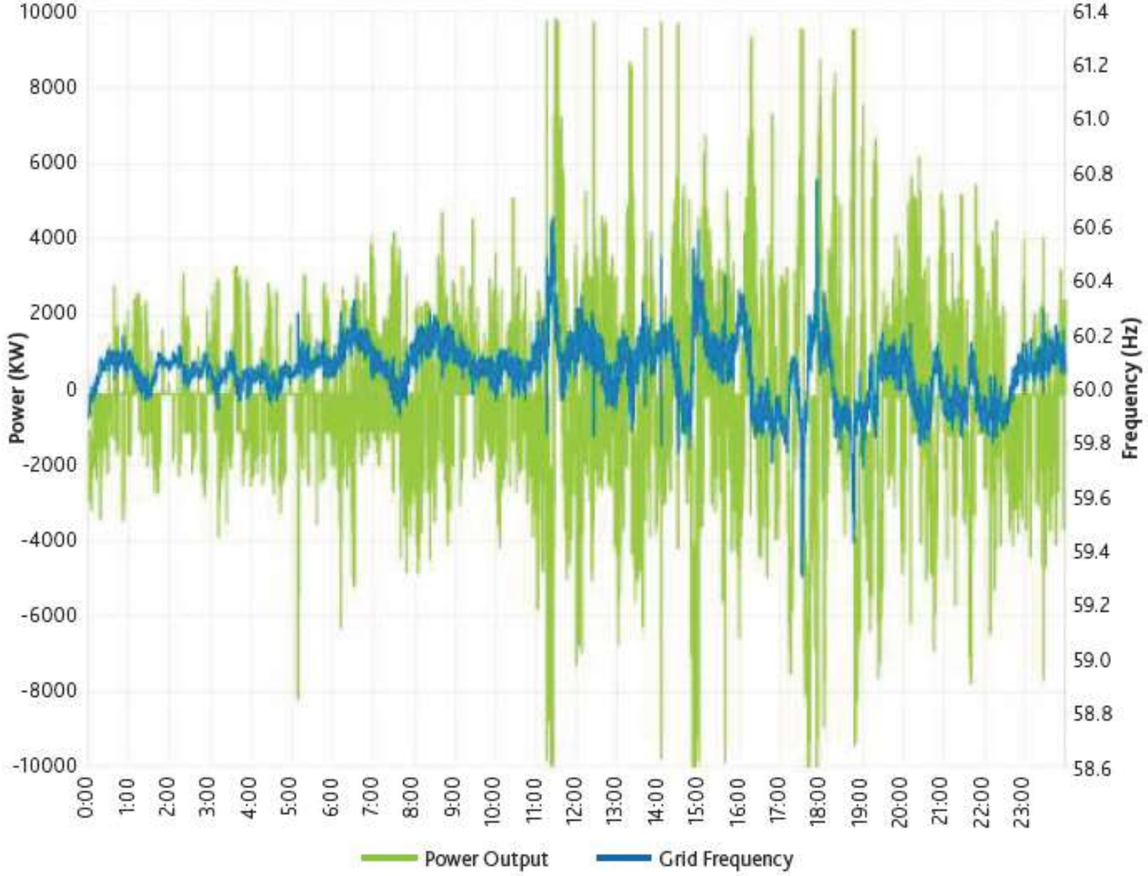
In Dominican Republic, battery storage remained online through Hurricane Irma in 2017 while generators and loads tripped offline

LOS MINA DPP



Operation during typical weather conditions | August 31, 2017

One week prior to Hurricane Irma



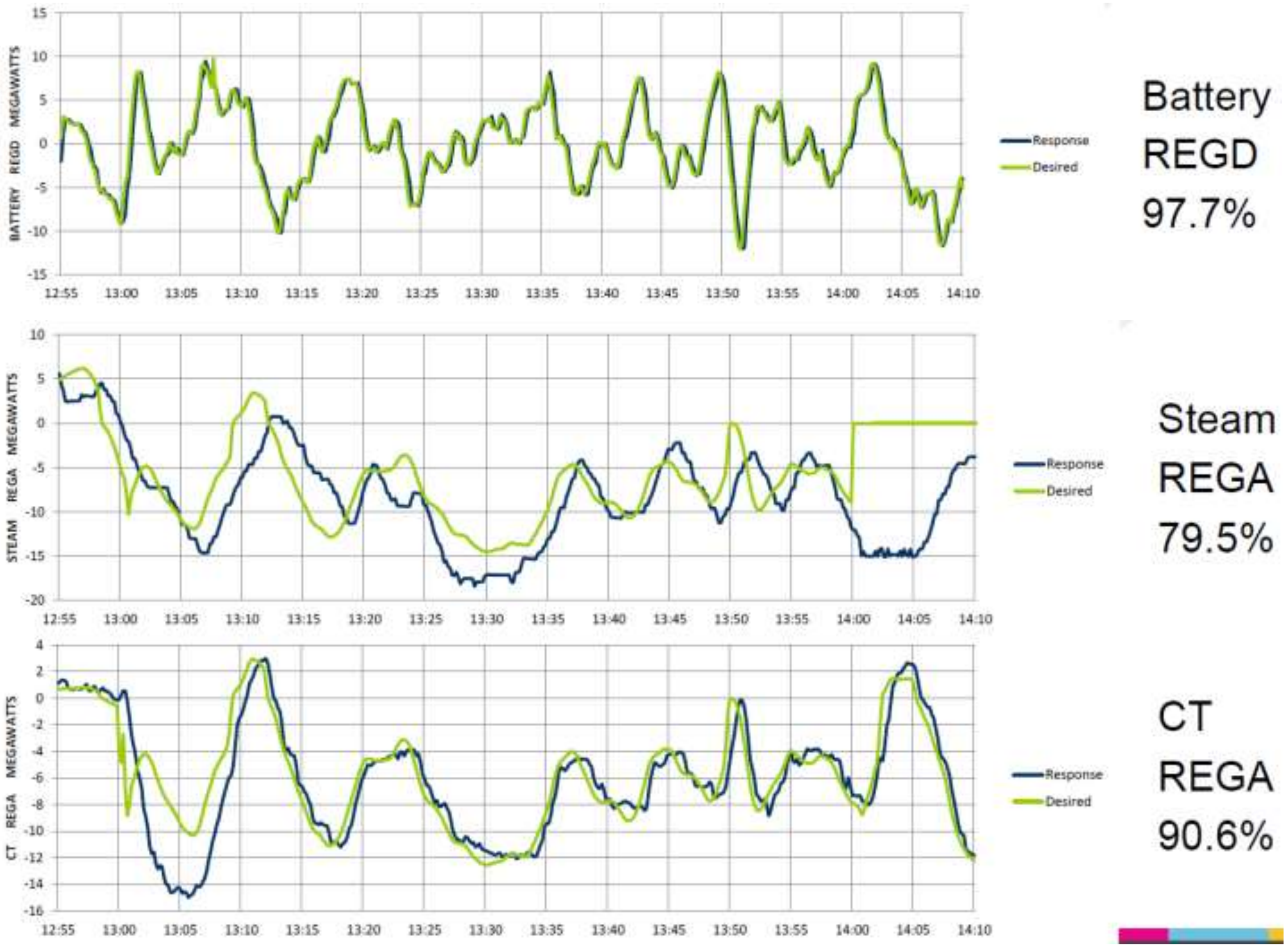
Operation during severe storm conditions | September 7, 2017

During Hurricane Irma

SOURCE: AES

Battery storage for grid stability: Fast frequency regulation

- Batteries meet 2-4 second signal more precisely than generators
- ~270 MW of storage in PJM fast frequency regulation (RegD) market
  - Includes BTM storage as demand response
- RegD reduced overall regulation reserve requirement by 30%



SOURCE: PJM

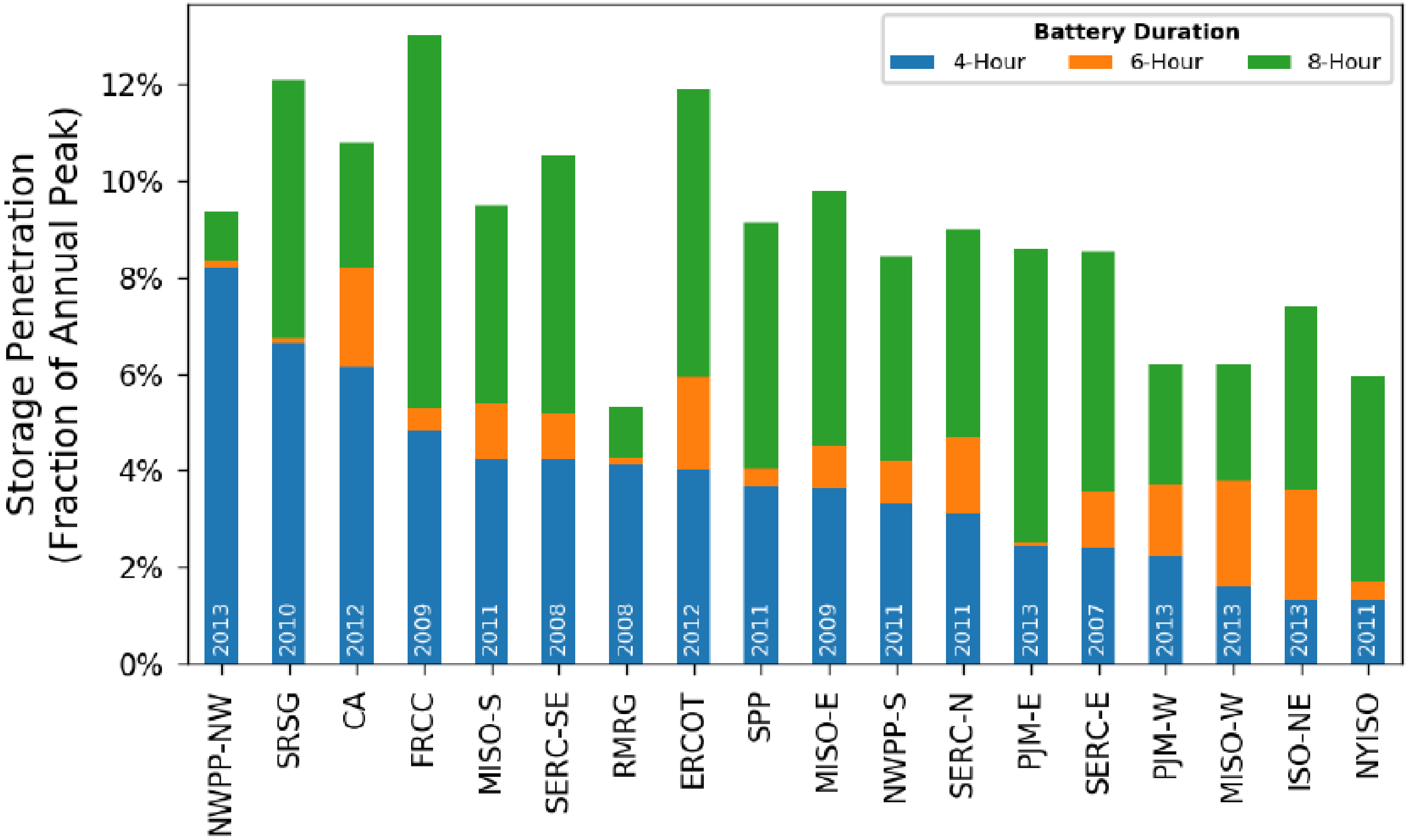
The Potential for Battery Energy Storage to Provide Peaking Capacity in the United States

(SOURCE: NREL 2019)

Findings for 4-hr storage:

- 28 GW of capacity potential nationwide
- 2-8% of system peak across regions

Peaking capacity potential increases with more wind/solar



Storage Selected Economically in IRPs 2018-2019

- Over 7.6 GW of storage proposed in IRPs *(not including TVA)*
- Notable *procurements* include 690 MW from NVE and 500 MW from APS
- Some proposals are geared to piloting technology

State	Utility	IRP Year	Storage Proposed	Timeline
IN	IPL	2016	833	over 20 years
HI	HECO	2016	535	2020
OR	PGE	2016	39.8	2020
KY	Kentucky Power	2016	10	over 10 years
CO	Xcel	2016 (2018 update)	275	2030
WA	Puget Sound	2017	75	2029
NC	Duke Carolinas	2017	75	2019-2021
AZ	UNS Energy Corp	2017	20	2028
WA	Avista	2017	5	2029
OR	PacifiCorp	2017	4	2020
MI	Consumers	2018	450	2040
NC	Duke Carolinas & Duke Pro	2018	290	2026
NM	El Paso Electric	2018	115	2035
NV	NVE	2018	100	2021
IN	NIPSCO	2018	92	2023
FL	FPL Energy	2018	50	2020
VA	Dominion	2018	30	2025
VA	Appalacian Power	2018	10	2025
NV	NVE	2019	590	2023
AZ	APS	2019	500	2025
FL	FPL Energy	2019	409	2022
PNM	New Mexico	2019	130	2023
GA	Georgia Power	2019	80	2024
OR	Idaho Power	2019	60	2034-2038
MI	Indiana Michigan Power	2019	50	2028
Multi	PacifiCorp	2019	2,800	2038
Total			**7,658**	

Note: Does not include TVA's recent 2019 IRP (5,300 MW x 2038 in preferred plan)

Report on *Storage in Integrated Resource Planning*

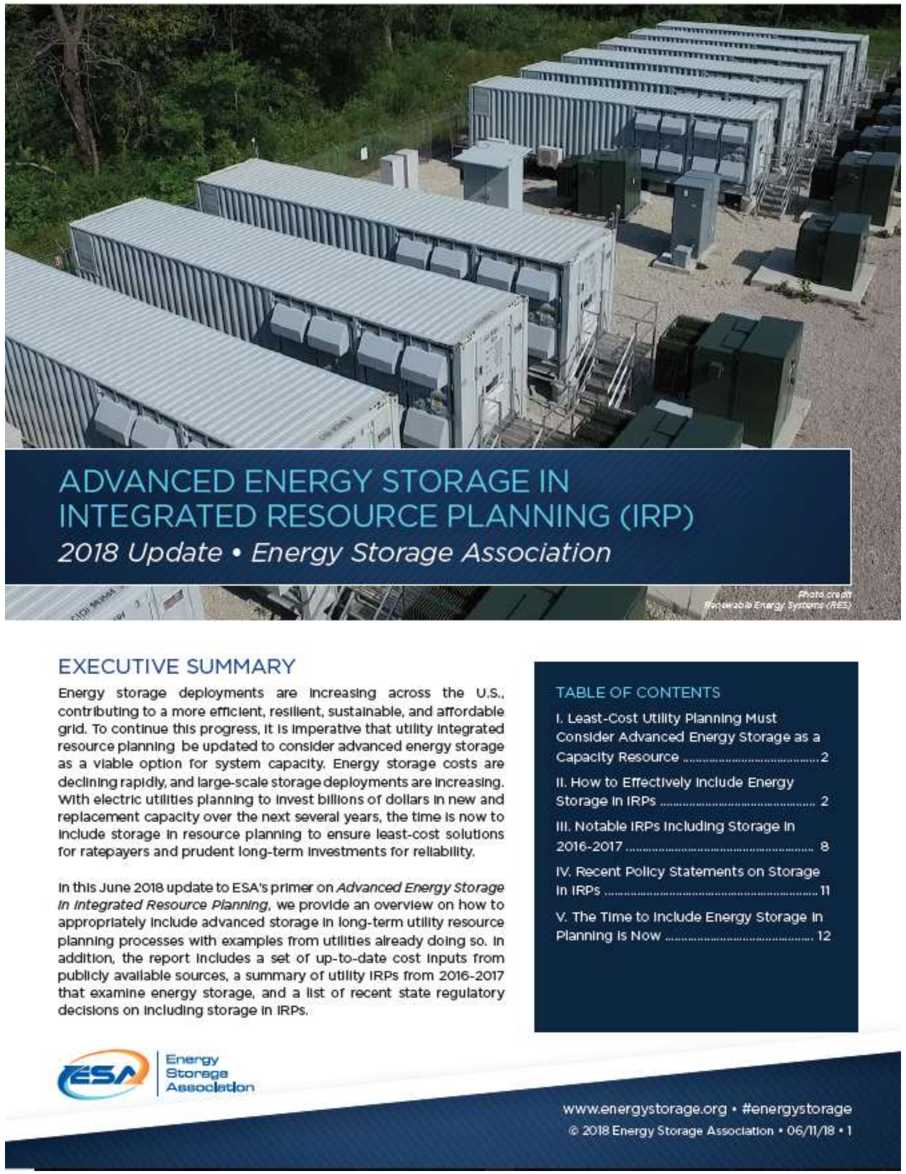
Key recommendations:

- Use up-to-date cost estimates and forecasts
- Employ models with sub-hourly time intervals
- Use a net-cost analysis of capacity investment options
- Quantify system flexibility needs & consider value for risk management

Also inside:

- Catalogues 2016-2017 utility IRPs that consider storage, highlighting best practices
- Summarizes actions on storage in IRPs from state utility commissions

Find the report at energystorage.org/IRP



ADVANCED ENERGY STORAGE IN INTEGRATED RESOURCE PLANNING (IRP)

2018 Update • Energy Storage Association

Photo credit: Renewable Energy Systems (RES)

EXECUTIVE SUMMARY

Energy storage deployments are increasing across the U.S., contributing to a more efficient, resilient, sustainable, and affordable grid. To continue this progress, it is imperative that utility integrated resource planning be updated to consider advanced energy storage as a viable option for system capacity. Energy storage costs are declining rapidly, and large-scale storage deployments are increasing. With electric utilities planning to invest billions of dollars in new and replacement capacity over the next several years, the time is now to include storage in resource planning to ensure least-cost solutions for ratepayers and prudent long-term investments for reliability.

In this June 2018 update to ESA's primer on *Advanced Energy Storage in Integrated Resource Planning*, we provide an overview on how to appropriately include advanced storage in long-term utility resource planning processes with examples from utilities already doing so. In addition, the report includes a set of up-to-date cost inputs from publicly available sources, a summary of utility IRPs from 2016-2017 that examine energy storage, and a list of recent state regulatory decisions on including storage in IRPs.

TABLE OF CONTENTS

ESA Energy Storage Association

www.energystorage.org • #energystorage