SAND2020-10085C

ENERGY STORAGE DEPLOYMENTS IN THE US TODAY

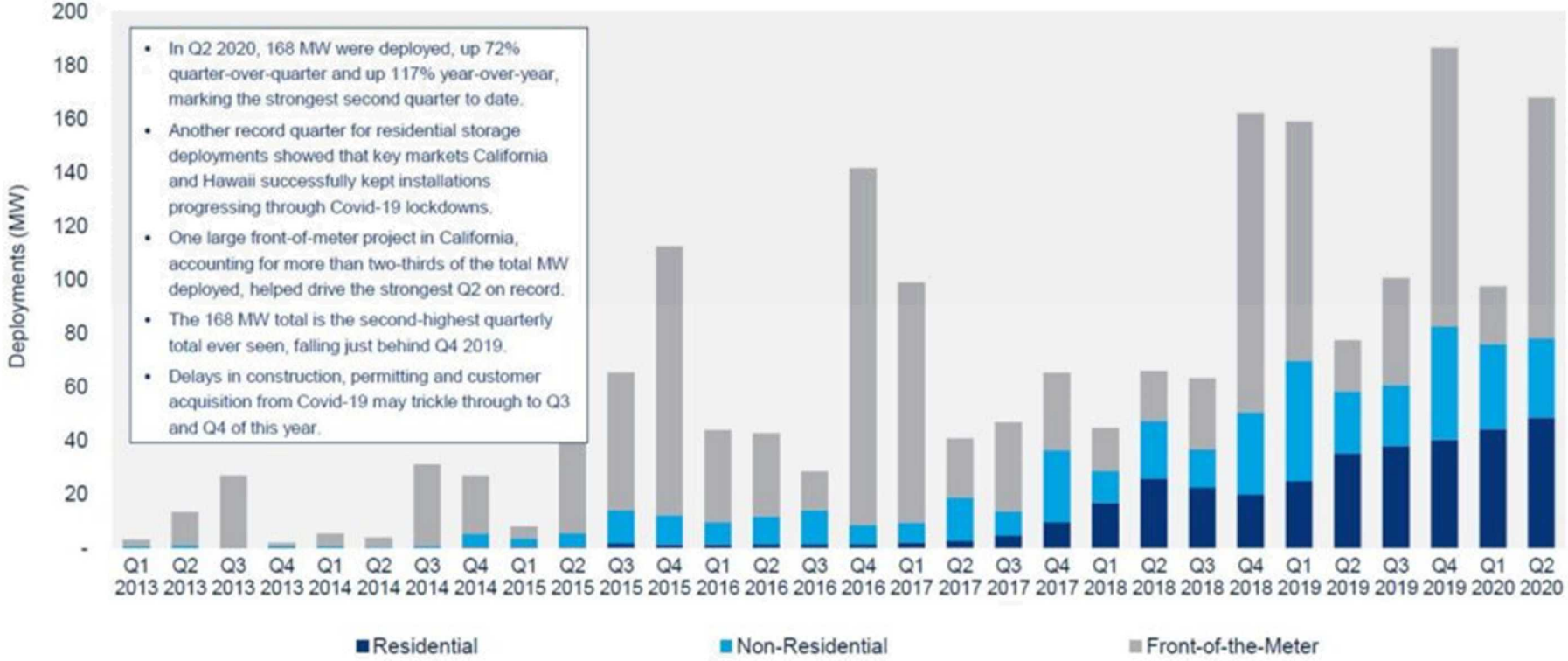
IEEE ES Tutorial for FERC, Wed., Sept. 23

Howard Passell, Ph.D., Energy Storage Systems, SNL

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

U.S. Q2 2020 deployments reached 168 MW

The strongest Q2 on record for deployments; Covid-19 pandemic has not hampered the downstream market



Source: Wood Mackenzie Power & Renewables

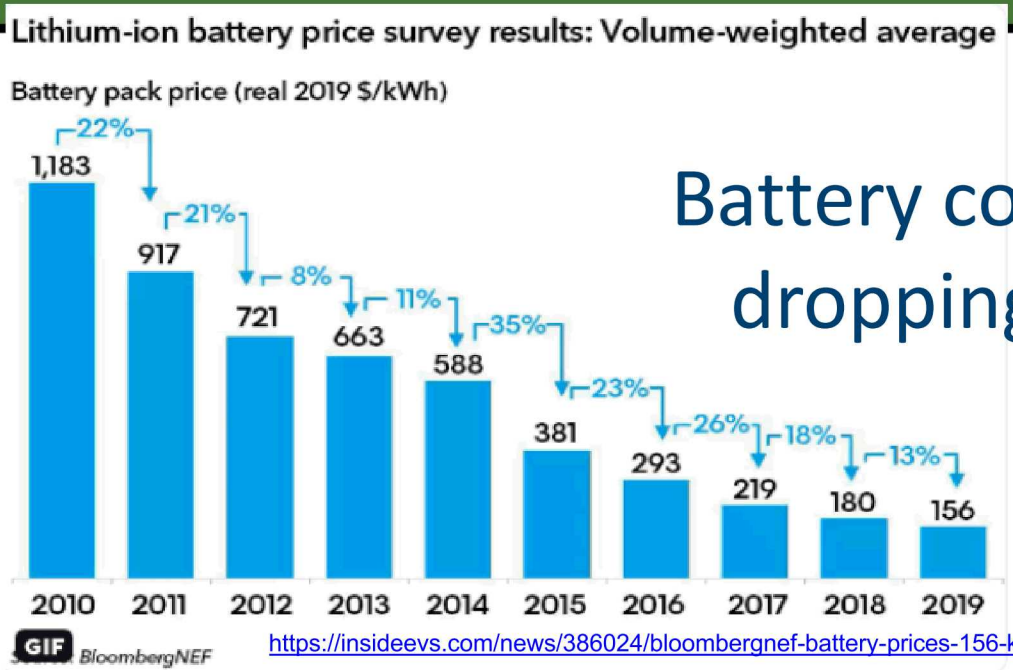
U.S. energy storage deployments will reach 7 GW annually in 2025

Covid-19 creates near-term downside due to customer-acquisition issues, installation/interconnection delays

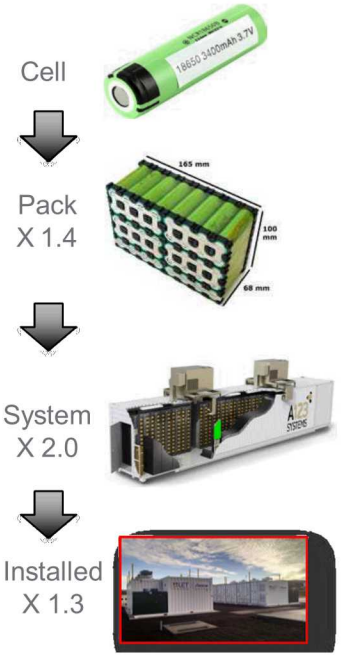
U.S. energy storage annual deployment forecast, 2012-2025E (MW)

Source: Wood Mackenzie Power & Renewables

Battery costs are dropping fast



https://insideevs.com/news/386024/bloombergnef-battery-prices-156-kwh-2019/



Bloomberg NEF predicts $100/kWh (pack cost) in 2023

$150/kWh cell → **$~750/kWh system**

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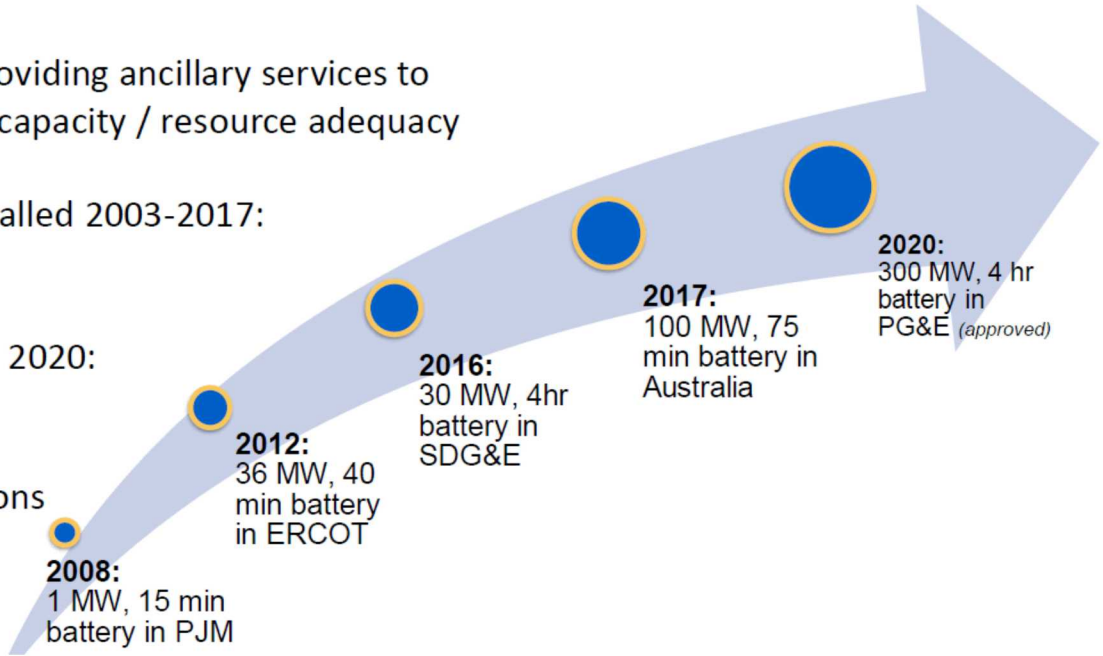
As costs go down, size and duration go up

Shift from primarily providing ancillary services to increasingly providing capacity / resource adequacy

All battery storage installed 2003-2017:
800 MW / 1200 MWh

Single PG&E battery in 2020:
300 MW / 1200 MWh

DER storage aggregations to follow (largest today ~20 MW)



Smart Electric Power Alliance (SEPA)
Top 10 Utility Battery Energy Storage Rankings

Top 10 Utilities by ES Capacity (MWh)

1 **Southern California Edison** California 154.5
2 **Kauai Island Utility Cooperative** Hawaii 102.6
3 **Pacific Gas & Electric** California 73.2
4 **Florida Power & Light Company** Florida 36.0
5 **Salt River Project** Arizona 44.5
6 **Long Island Power Authority** New York 42.0
7 **San Diego Gas & Electric** California 33.7
8 **Connexus Energy** Minnesota 30.0
9 **Hawaiian Electric Company** Hawaii 23.3
10 **United Power, Inc.** Colorado 18.2

Top 10 Utilities by Annual ES Watt-Hours/Customer (Wh/C)

1 **Kauai Island Utility Cooperative** Hawaii 3,037.6
2 **Sterling Municipal Light Department** Massachusetts 523.1
3 **City of Holyoke** Massachusetts 341.6
4 **Braintree Electric Light Department** Massachusetts 240.5
5 **Connexus Energy** Minnesota 226.8
6 **United Power, Inc.** Colorado 218.9
7 **Hawaii Electric Light Company** Hawaii 95.2
8 **Hawaiian Electric Company** Hawaii 76.3
9 **Green Mountain Power Corporation** Vermont 66.3
10 **Salt River Project** Arizona 42.6

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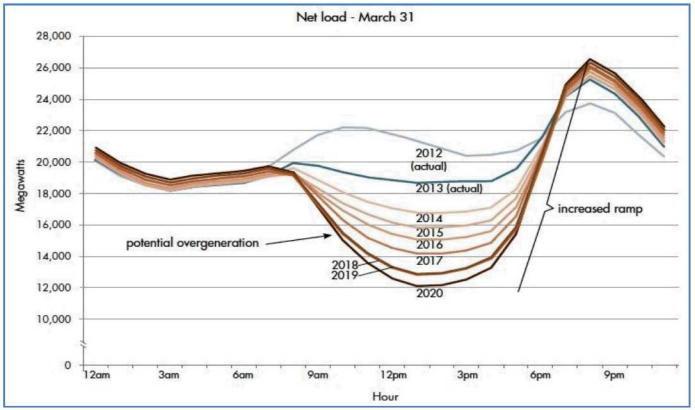
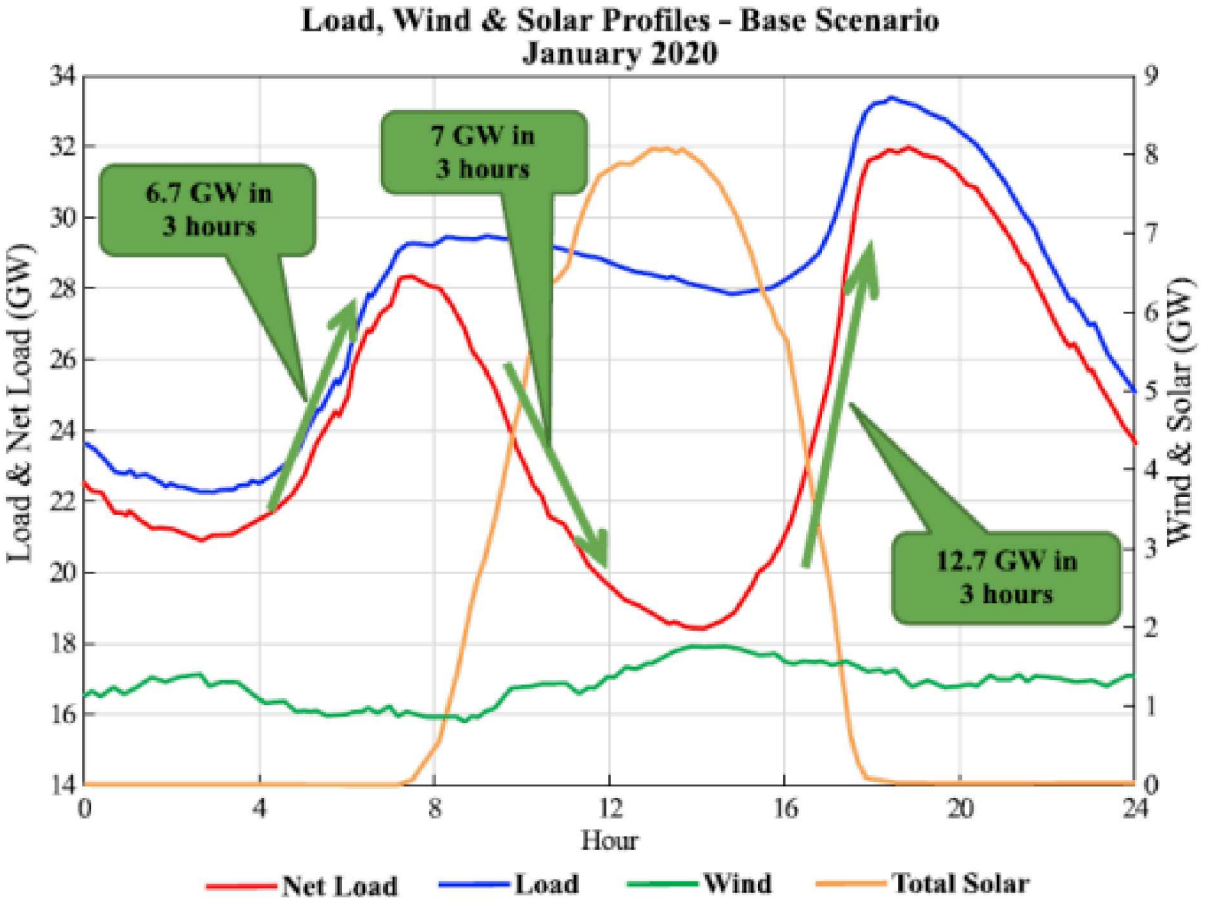
CA Duck Curve





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California Projections, MW, 2020-2030

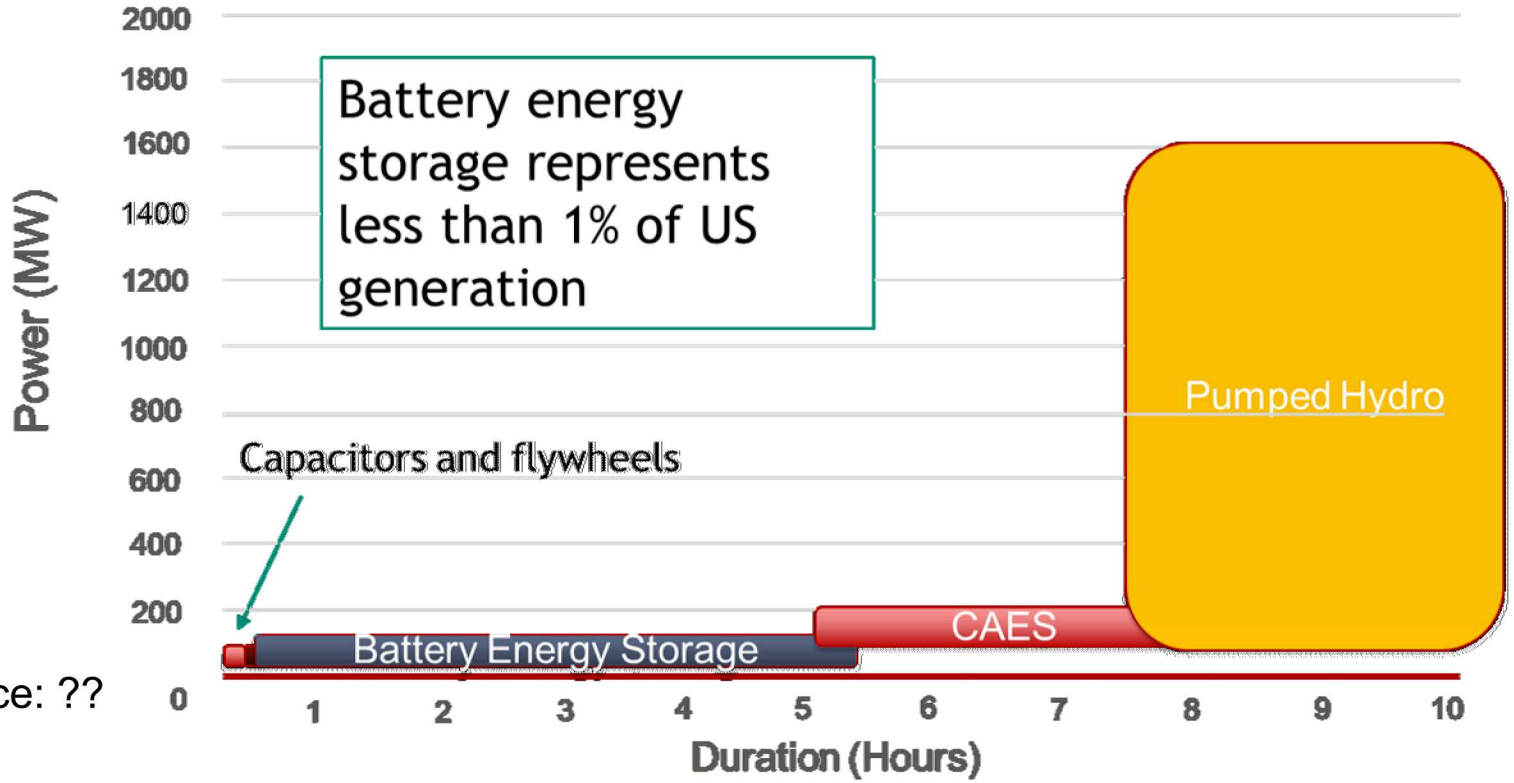
- Wind x 83
- PV x 5.5
- Batteries x 58

Energy Storage is catching up!

Resource Type	2020	2021	2022	2023	2024	2026	2030
Wind	-	34	1,950	1,950	2,737	2,737	2,837
Wind on New Out-of-State Transmission	-	-	-	-	-	-	606
Utility-Scale Solar	2,000	4,000	6,000	8,000	8,000	8,000	11,017
Battery Storage	152	2,453	2,453	2,453	3,299	6,127	8,873
Pumped (long-duration) Storage	-	-	-	-	-	973	973
Shed Demand Response	-	222	222	222	222	222	222
Natural Gas Capacity Not Retained	-	-	-	-	-	-	(30)

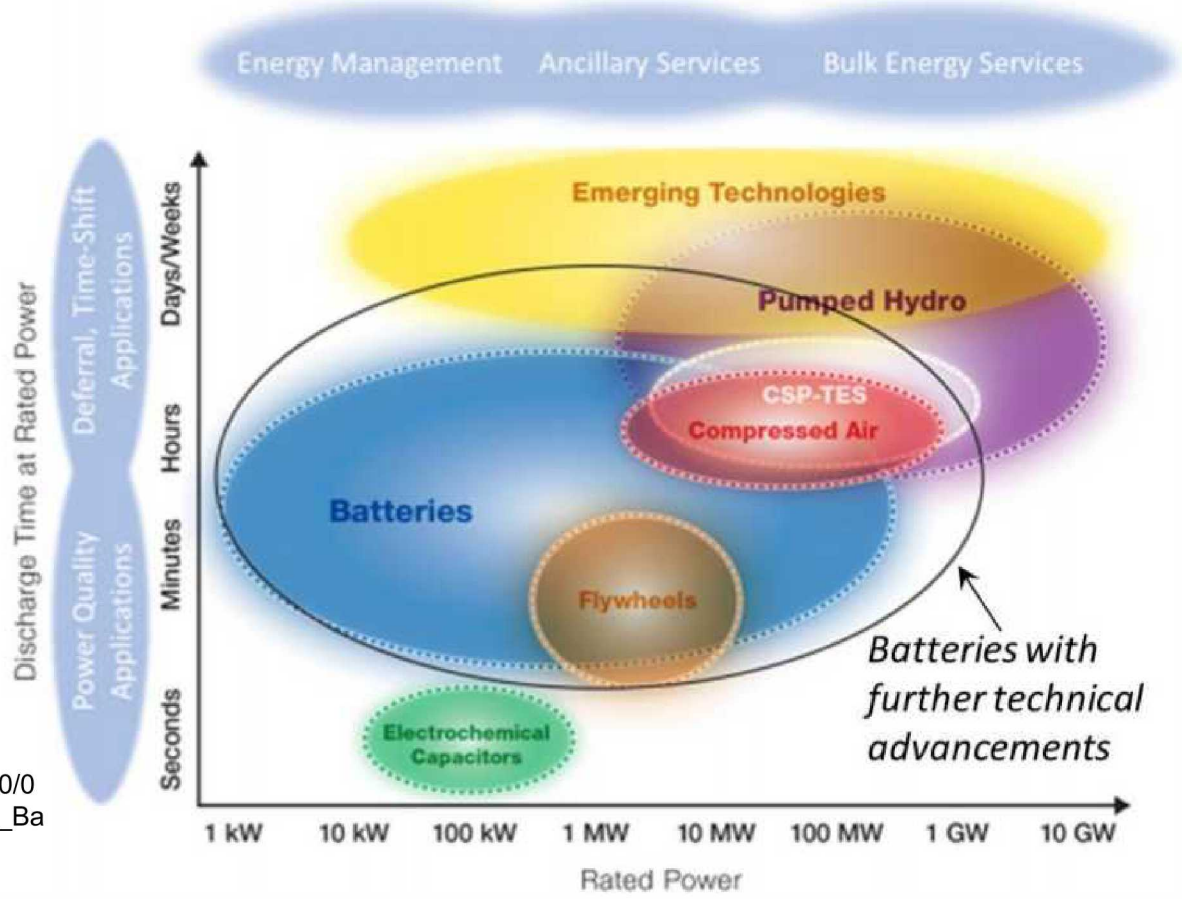
Courtesy of Mike Gravely, CEC

Energy Storage Technologies



Source: ??

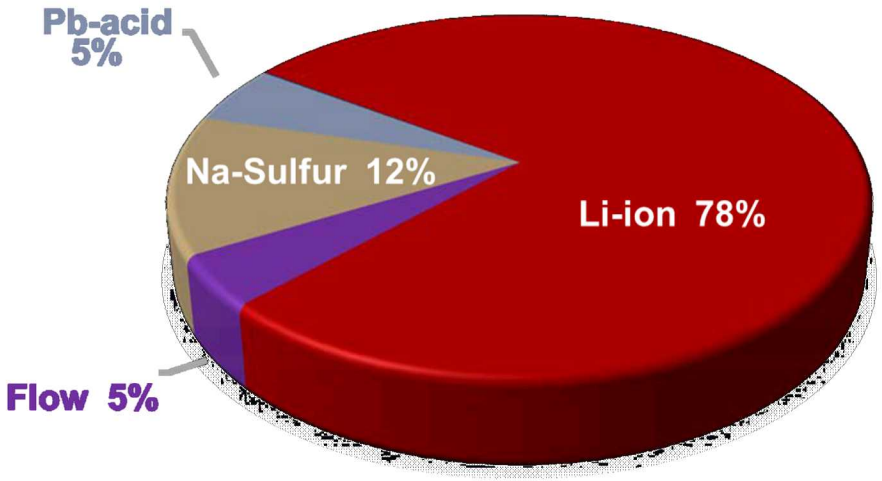
Duration/power graphs for leading battery chemistries

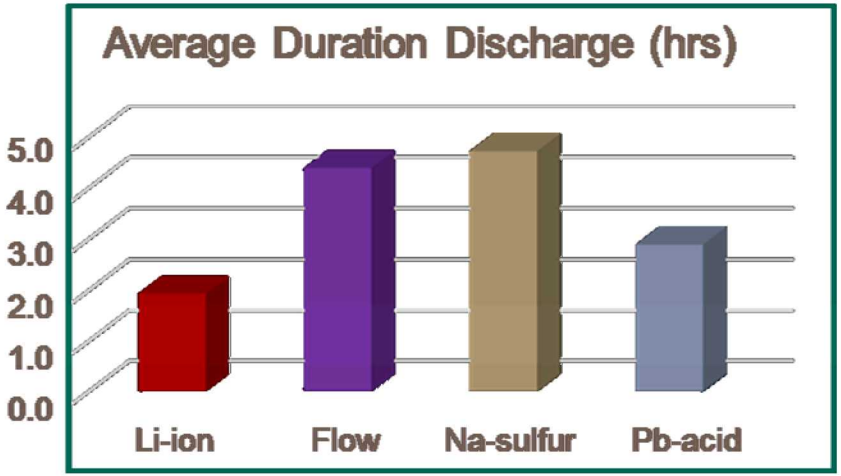


Potential Benefits of High-Power High-Capacity Batteries, DOE Report, Jan 2020

https://www.energy.gov/sites/prod/files/2020/02/f71/Potential_Benefits_of_High_Powered_Batteries_Report.pdf

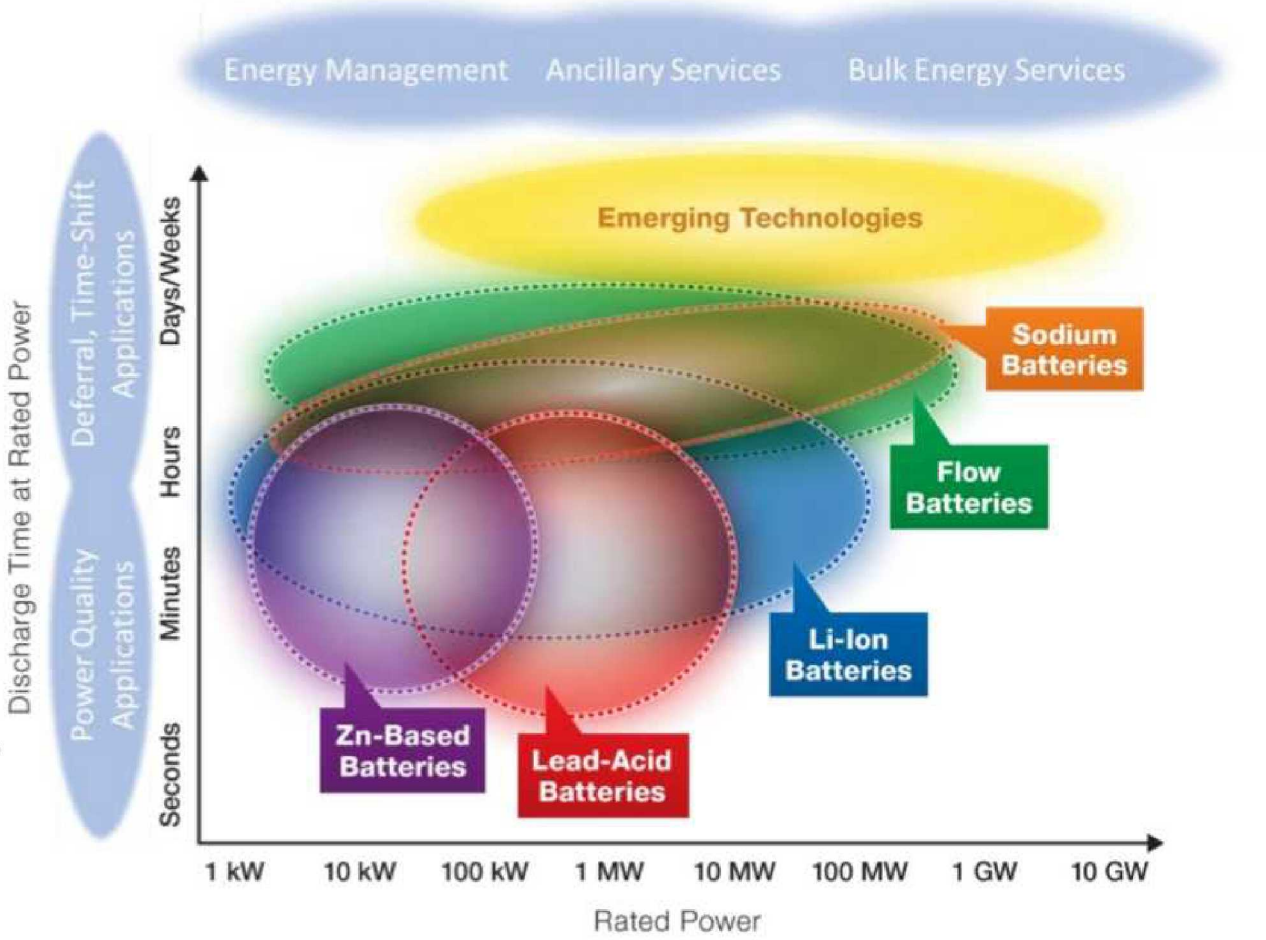
Battery Deployments





Source: *DOE Global Energy Storage Database http://www.energystorageexchange.org/, Nov. 2017*

Duration/power graphs for leading battery chemistries



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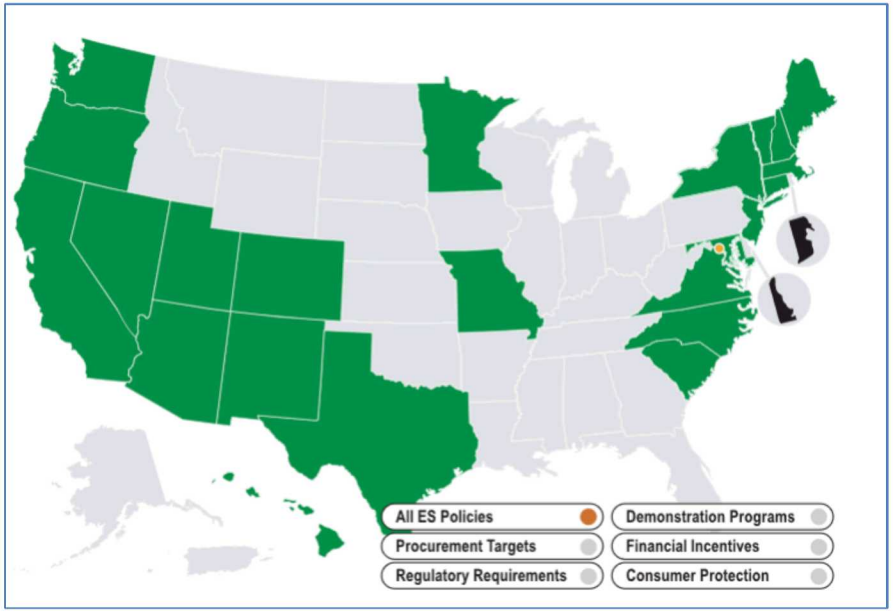
Racoon Mountain pumped hydro 1,652 MW -- 22 hours

Lithium ion equivalent,
~20 billion 18650 cells,
~3x distance to the moon

"If most of the renewables increase comes [for CA decarbonization] from solar deployments, that means a nearly 75-fold increase in storage capacity would be needed to satisfy the conditions seen on August 15th . . . and nearly $90 billion in capital expenditures . . .

https://www.forbes.com/sites/brentanalexander/2020/08/22/california-blackouts-show-natural-gas-is-needed-for-a-stable-grid-for-now/#135e222f2e91

Energy Storage Policy Database, PNNL



GESDB -- https://energystorage.pnnl.gov/regulatoryactivities.asp

Energy Storage in Integrated Resource Plans, Wood Mackenzie

Wood Mackenzie/ESA Energy Storage Monitor: 3rd Quarter U.S. Energy Storage Review

Drivers and Challenges

- Climate Change
- Grid Modernization
- Electrification
- Long Term Storage
- Other Technologies
- Other Chemistries
- Interconnection
- Regulatory
- Finance
- Safety

Many resources are available

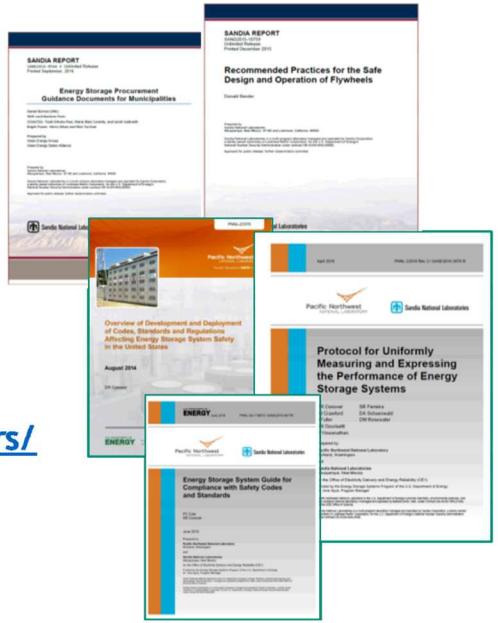
DOE Energy Storage Systems Website
https://www.sandia.gov/ess-ssl/

DOE Global Energy Storage Database
https://www.energystorageexchange.org/

Clean Energy States Alliance (CESA) https://www.CESA.org

Energy Storage Technology Advancement Partnership
https://www.cesa.org/projects/energy-storage-technology-advancement-partnership/ AND https://www.cesa.org/webinars/

Clean Energy Group Webinars
https://www.cleanegroup.org/webinars/



Utility Dive
https://www.utilitydive.com/

Energy Storage Association
https://energystorage.org/

The Energy Transition Show
https://xenetwork.org/ets/

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Summary Points

- Battery technology is improving, spreading, getting cheaper, getting safer, and is expected to boom.
- MUCH more battery capacity with longer durations is required to meet 100% carbon free goals and across the country.
- Supply chain, toxicity, waste, end of life issues, recycling, cradle to cradle design, all still nascent
- Li-ion overwhelms the market, but many other chemistries and technologies are in development
- Batteries can provide important services to the grid, and many value streams, but some of those values are hard to quantify, and markets don't exist
- PV + batteries is already outcompeting new and existing gas peaker plants