

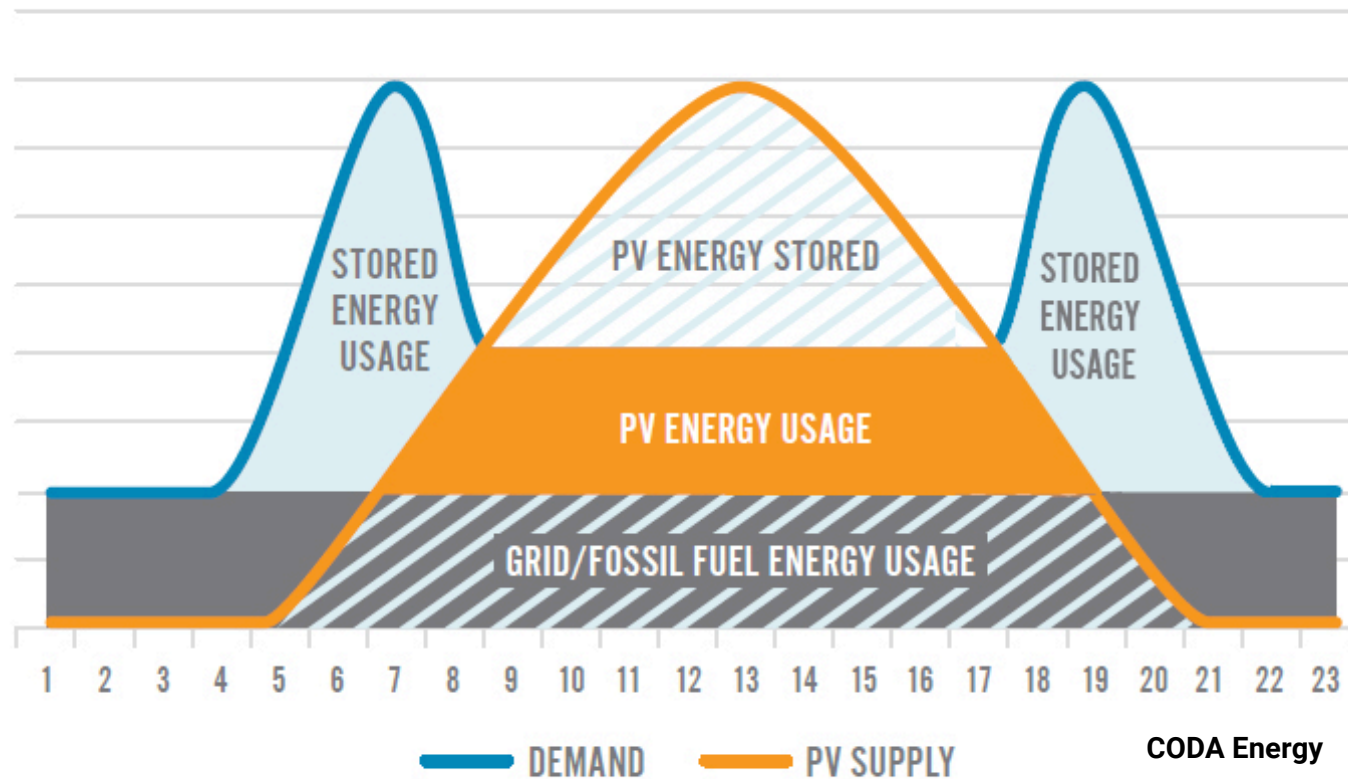
Duration Addition to electricitY Storage (DAYS)



Scott Litzelman, Max Tuttmann (ARPA-E)

Rusty Heffner, Vivien Lecoustre, Sean Vail (Booz Allen Hamilton)

Storage applications today



Examples of other applications:

Frequency regulation

Flexible ramping

Power quality

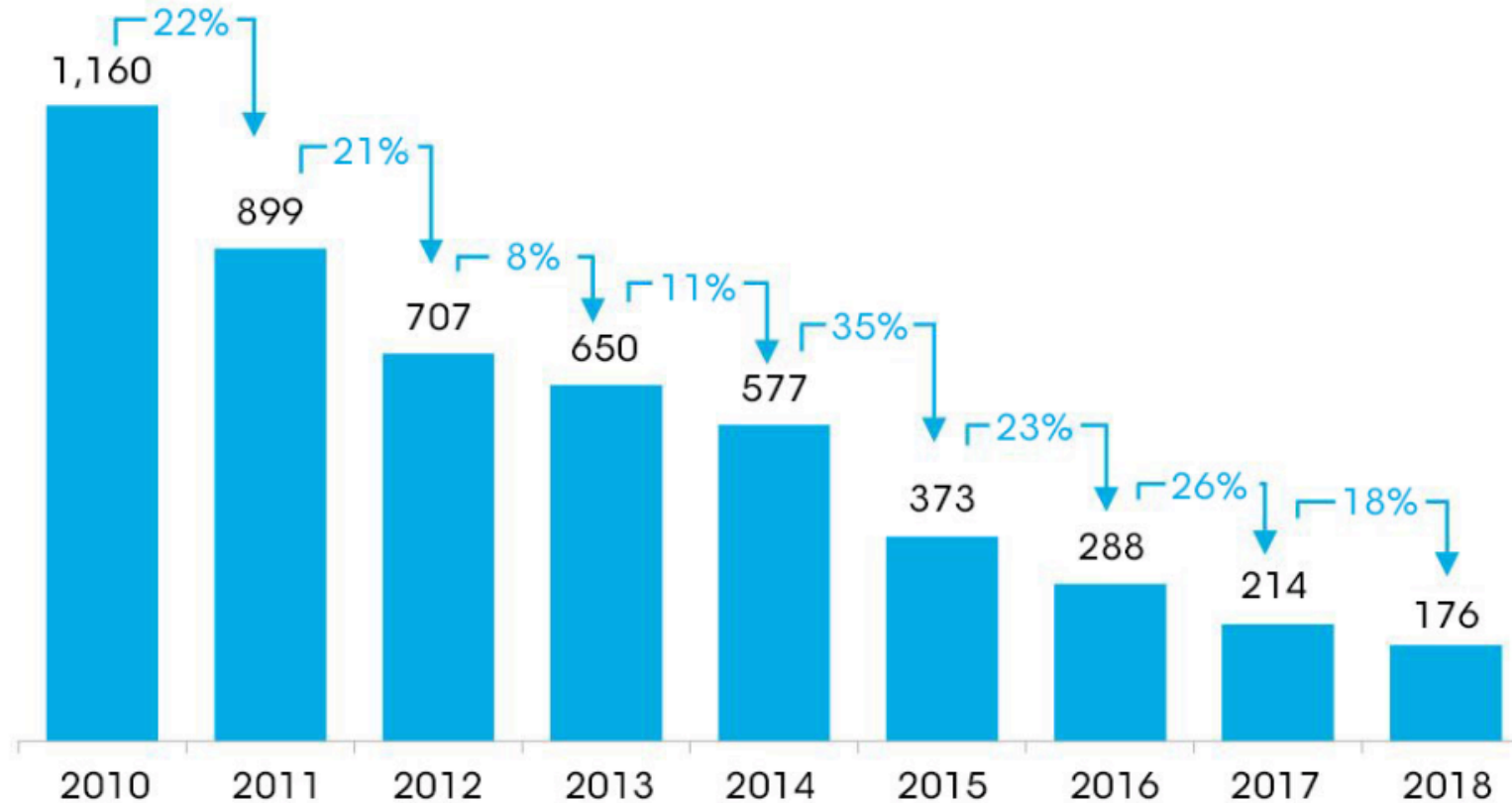
Distribution upgrade deferral

Demand charge management

Li-ion prices (pack level)

Lithium-ion battery price survey results: volume-weighted average

Battery pack price (real 2018 \$/kWh)

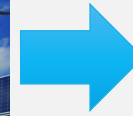


2019: \$156/kWh

Source: BloombergNEF

LDES value unlocked at high VRE deployment levels

Firming Output of Variable Renewables

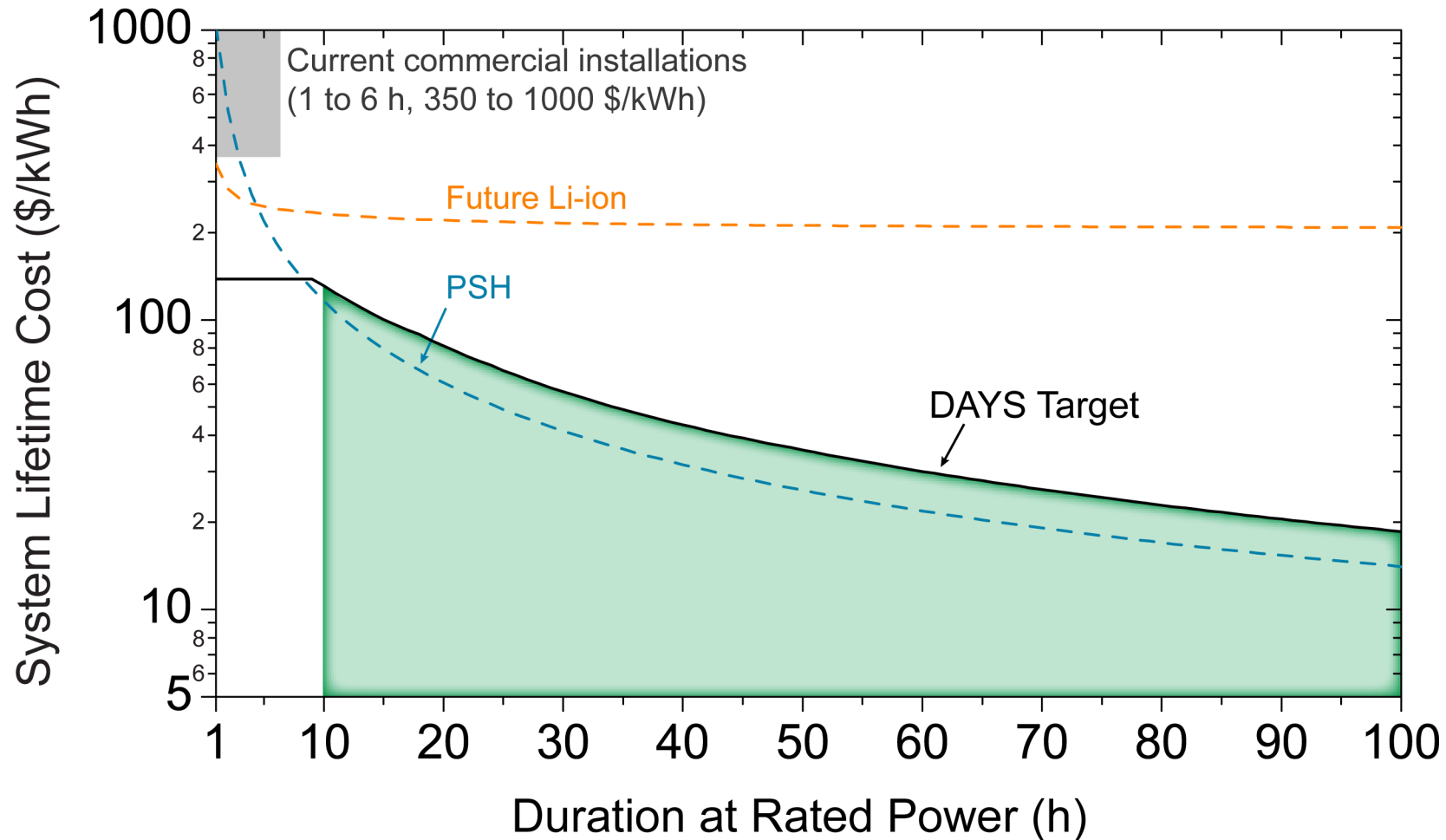


Ensuring System Resiliency



DAYS: pumped hydro-like costs but sited anywhere

10-100 hours of discharge at 5 ¢/kWh-cycle



The DAYS portfolio

Thermal

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ALLIED MINERAL PRODUCTS

PURDUE UNIVERSITY

GREENWAY ENERGY
AN ENERGY SOLUTIONS COMPANY

GE Global Research

POWER ENGINEERS

COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

Brayton Energy LLC

MIT Massachusetts Institute of Technology

SwRI
SOUTHWEST RESEARCH INSTITUTE

ECHOGEN
power systems

SOLEX

TU WIEN TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Westinghouse

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

MIT Massachusetts Institute of Technology

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Antora Energy

Lawrence Berkeley National Laboratory

ASU Arizona State University

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

MICHIGAN STATE UNIVERSITY

ASU Arizona State University

Saudi Aramco Energy Ventures

Electrochemical

form energy

VT VIRGINIA TECH.

MIT Massachusetts Institute of Technology

SEPION TECHNOLOGIES

THE UNIVERSITY OF TENNESSEE KNOXVILLE

Peroxygen Systems

PRIMUS POWER

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

United Technologies Research Center

MIT Massachusetts Institute of Technology

PennState

Lawrence Berkeley National Laboratory

Mechanical

Quidnet Energy

At this meeting



Design, build, and operate PTES systems



Component: reversing turbomachine



Not PTES; resistive heating



DAYS stakeholder outreach

Financial Partners



Market Researchers



Utilities



OEMs



Trade Groups



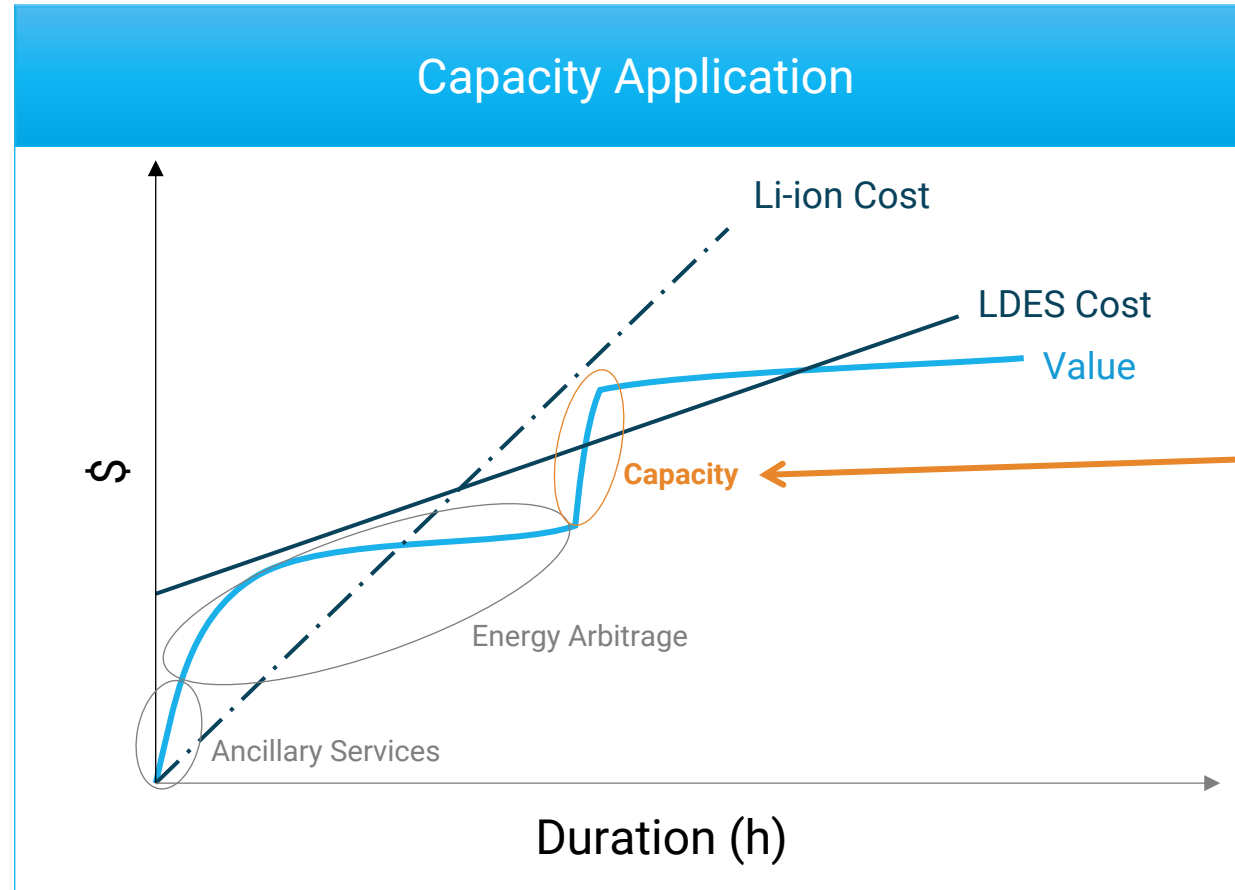
Energy Buyers



Public Partners



Future long-duration applications: capacity and risk mitigation



Capacity: displacing a physical asset, rather than fuel

Also: mitigating the risk of a given portfolio of assets

Key Pathways to Market

- ▶ Capacity Resource for load-serving entities^{1,2}
- ▶ Physical hedge for energy marketers³
- ▶ Self-consumption maximization for behind-the-meter generation⁴
- ▶ Clean backup power for critical loads^{5,6}
- ▶ T&D congestion relief for load pockets⁷
- ▶ Interconnection maximization for developers⁸

¹<https://www.utilitydive.com/news/moving-beyond-rules-of-thumb-for-smart-cost-effective-storage-deployment/553674/>

²<http://www.caiso.com/StakeholderProcesses/Resource-Adequacy-Enhancements>

³ARPA-E discussion with Skylar Energy

⁴<https://blog.aurorasolar.com/how-net-metering-is-evolving-three-changes-you-need-to-know>

⁵<https://www.utilitydive.com/news/pge-sce-abandon-big-microgrid-plans-for-temporary-emergency-measures-as-w/574506/>

⁶<https://www.utilitydive.com/news/2020-outlook-renewables-resilience-and-reliability-needs-will-drive-stora/569612/>

⁷<https://www.greentechmedia.com/articles/read/oakland-to-swap-jet-fueled-peaker-plant-for-urban-battery>

⁸<https://www.greentechmedia.com/articles/read/ladwp-plans-to-break-new-low-price-records-with-massive-solar-battery-proje>

Implications for this meeting

- ▶ The more known about the duty cycle, the better
- ▶ More round-trip efficiency might not be worth the capex
- ▶ Dynamics matter, but so do other factors
 - Stability at high state of charge
 - Self-discharge
- ▶ Will there be O&M concerns given the complexity?
- ▶ How to scale to big prototypes?