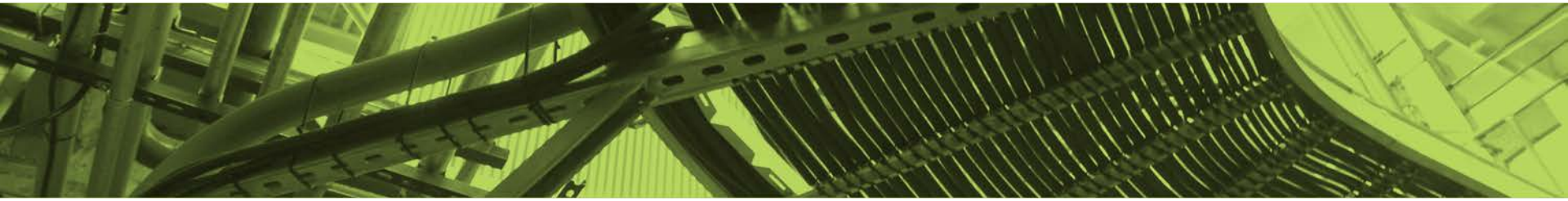
The Role of Energy Storage
In Pushing Toward 100% Renewable Energy



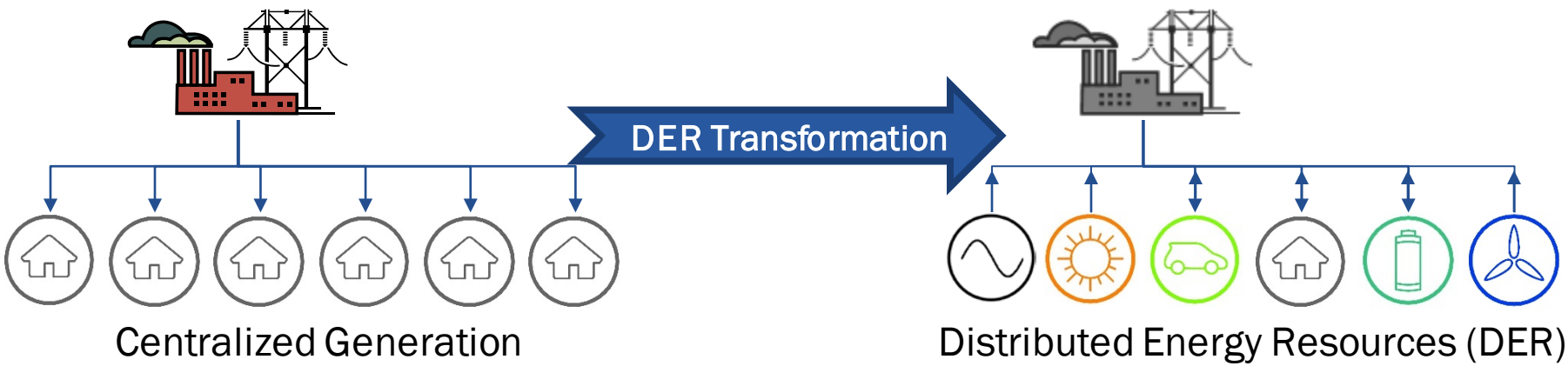
DRAWDOWN

Spirae

Alison Mason, January 2017

About Spirae

Localize Decarbonize Personalize



Spirae's Wave® software platform provides a scalable architecture for integrating and managing high levels of renewable and distributed energy resources (DER) at the edge of the grid.

I will cover…

- Flexibility
- Market Trends in Energy Storage
- What Energy Storage Can Do
- Why Energy Storage is Not the Holy Grail
- Cool Energy Storage Projects

What Are We Solving?

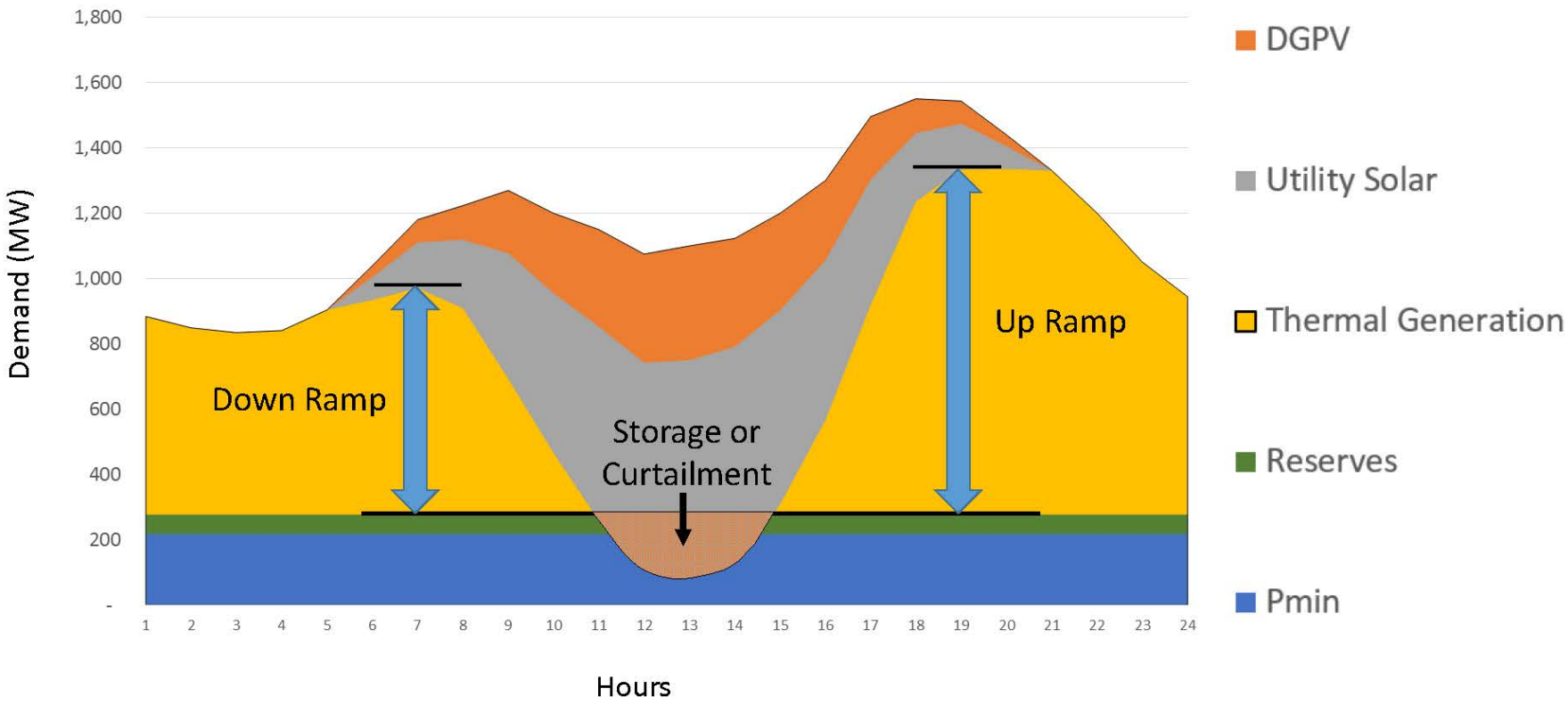
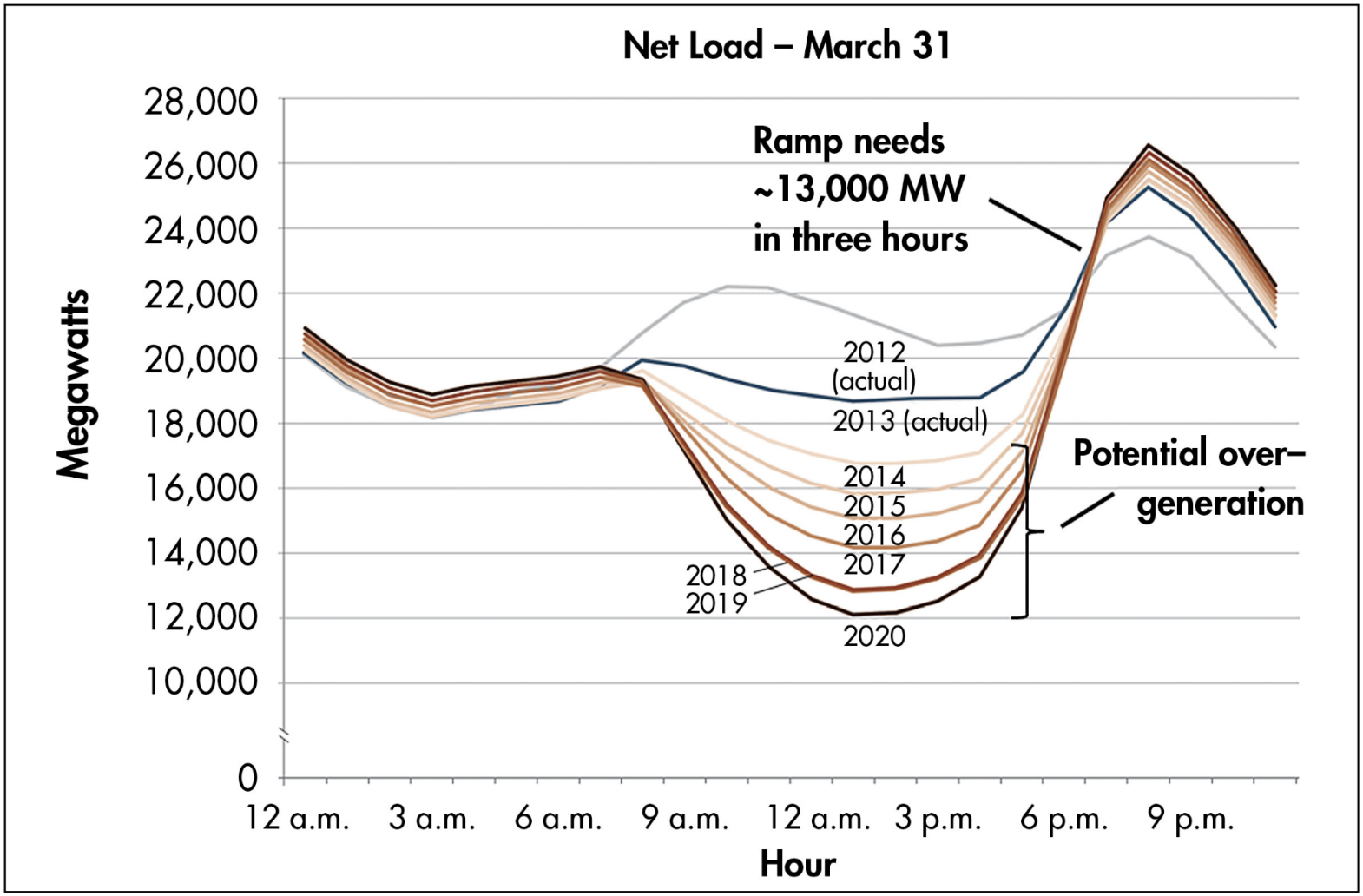


Figure 1: Net load on the CAISO system



Source: CAISO

FEATURE

How California utility regulators are turning electric vehicles into grid resources

DOE Global Energy Storage Database

Last Updated 8/16/2016 1:25:38 PM

Global Project Installations Over Time

Remove Pumped Hydro....

Rated Power (GW)

160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0

1929 1944 1951 1954 1956 1958 1960 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018

Technology
(Multiple values)

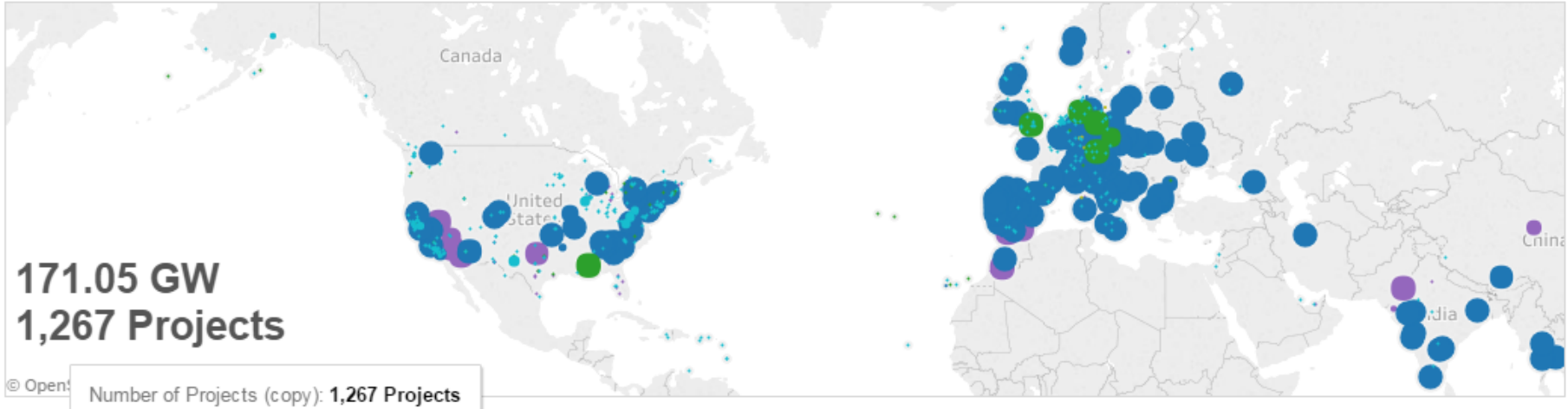
Status
Operational

Start Date
1905 2020

- Electro-chemical
- Electro-mechanical
- Hydrogen Storage
- Pumped Hydro Stor...
- Thermal Storage

Rated Power (MW)
- ≤ 20
- 40
- 60
- 80

Country
(All)



171.05 GW
1,267 Projects

© Open

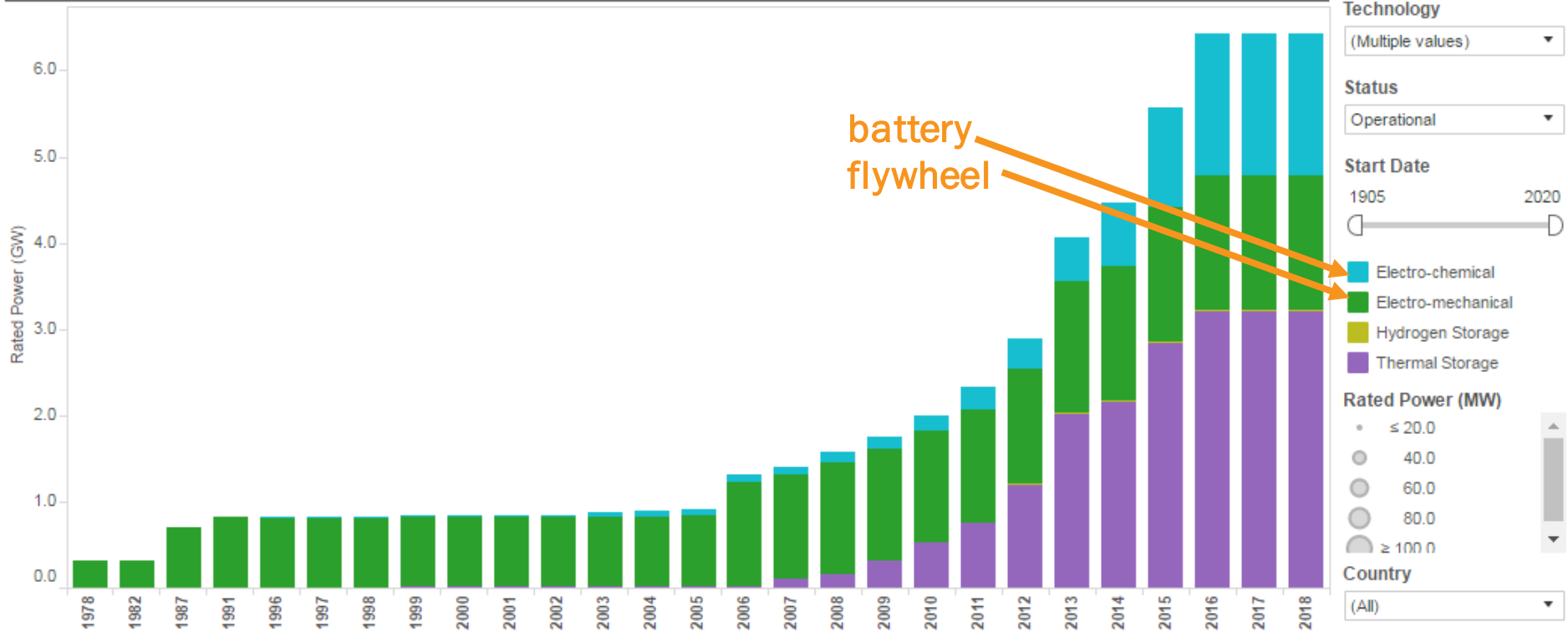
Number of Projects (copy): **1,267 Projects**

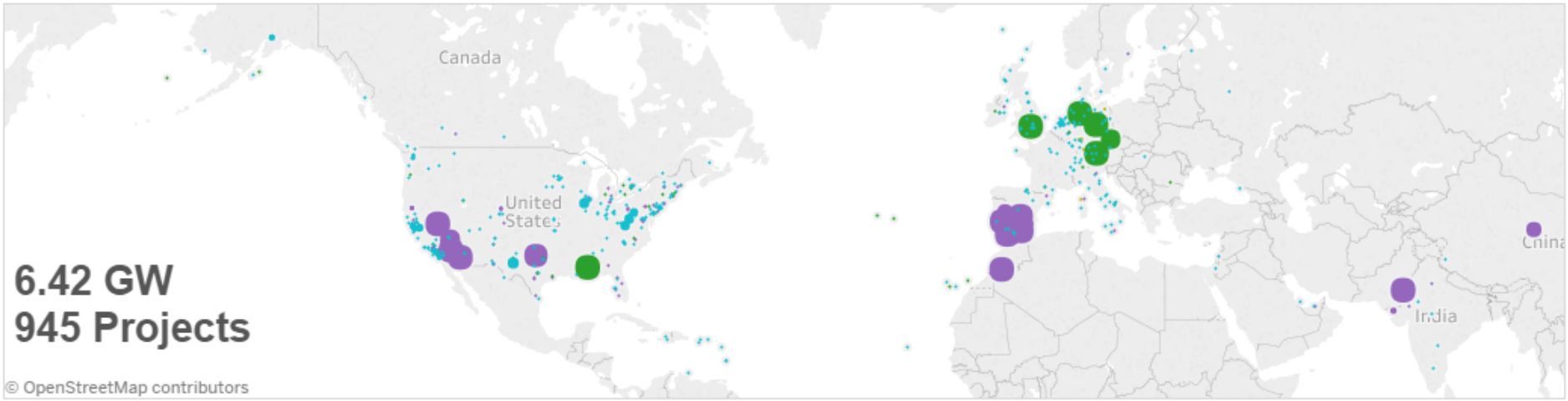
T ergystorageexchange.org/) is powered by Sandia Corporation (http://www.sandia.gov/) and Strategen Consulting , LLC (http://strategen.com/)

DOE Global Energy Storage Database

Last Updated 8/16/2016 1:25:38 PM

Global Project Installations Over Time





The DOE Global Energy Storage Database (http://www.energystorageexchange.org/) is powered by Sandia Corporation (http://www.sandia.gov/) and Strategen Consulting, LLC (http://strategen.com/)

What Kinds of Energy Storage?

Grid Scale Battery	Pumped Hydro	Flywheel
		
Ice Bear	Molten Salt	Hot Water
		

Molten Salt (Crescent Dunes)

Grid Scale Batteries

Residential Battery Systems

Sonnen

Sunverge

Tesla

Mercedes

DOE Global Energy Storage Database

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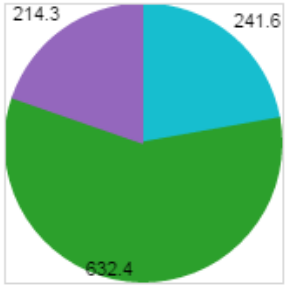
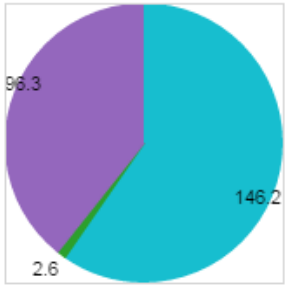
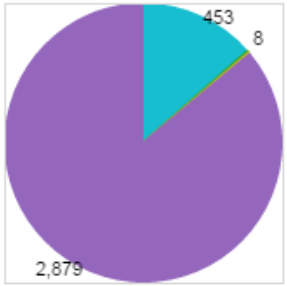
Electric Energy Timeshift (MW)*



Electric Bill Management (MW)*



Renewables Capacity Firming (MW)*



Technology

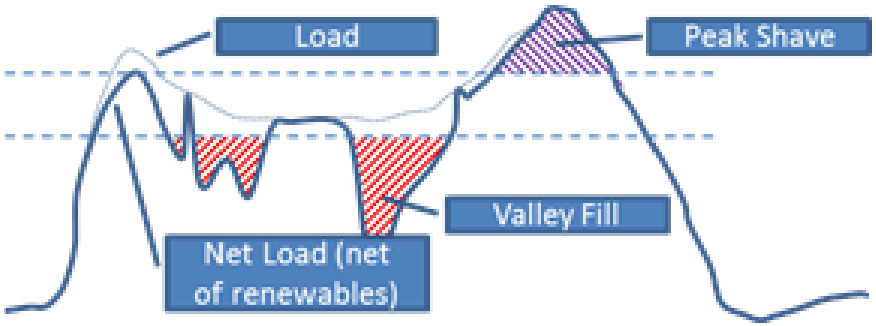
(Multiple values)

Status

Operational

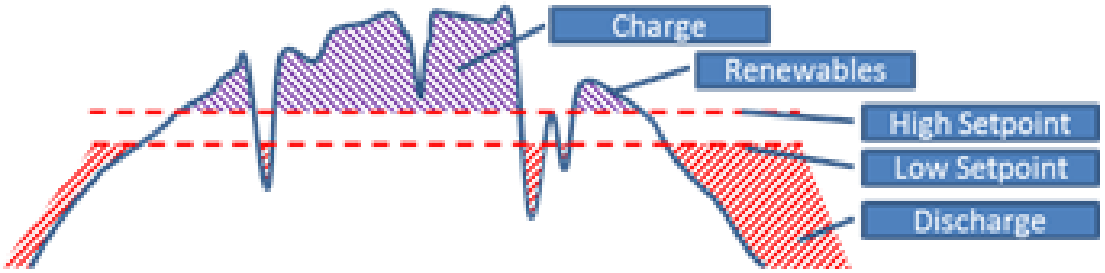
- Electro-chemical
- Electro-mechanical
- Thermal Storage

What is Energy Storage Doing?



Electric Energy Timeshift

Renewable Capacity Firming



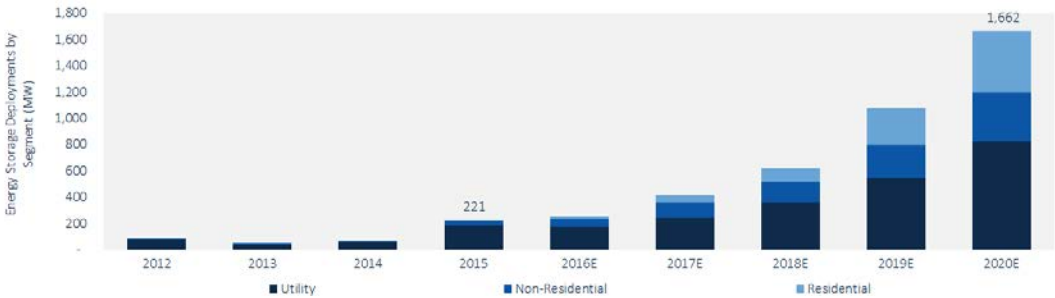
Reverse Power Flow

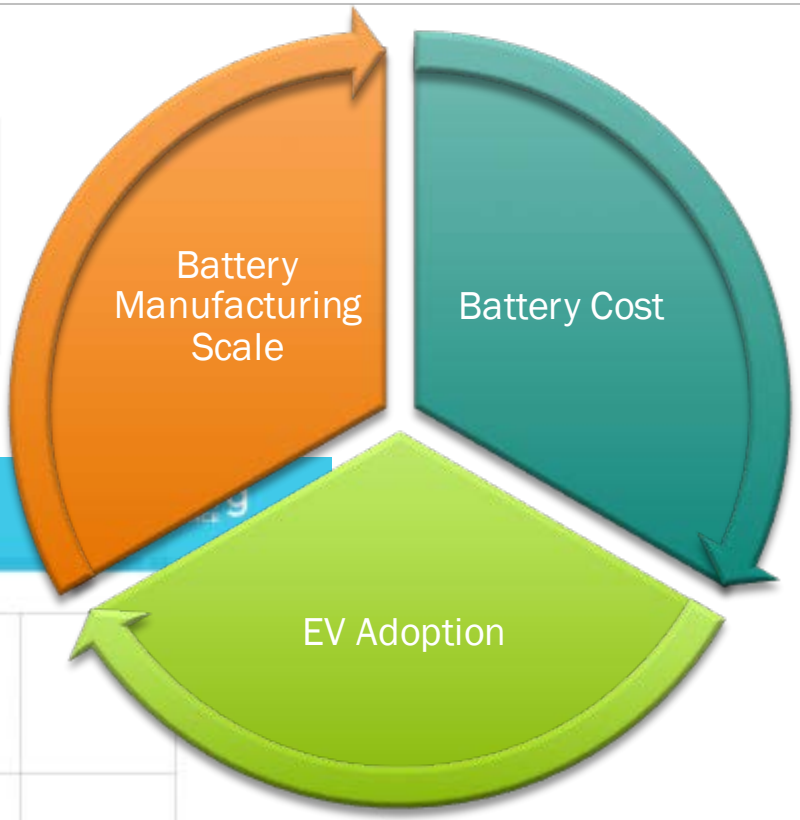
Figure 10: Storage Can Avoid Reverse Power Flows with Solar PV

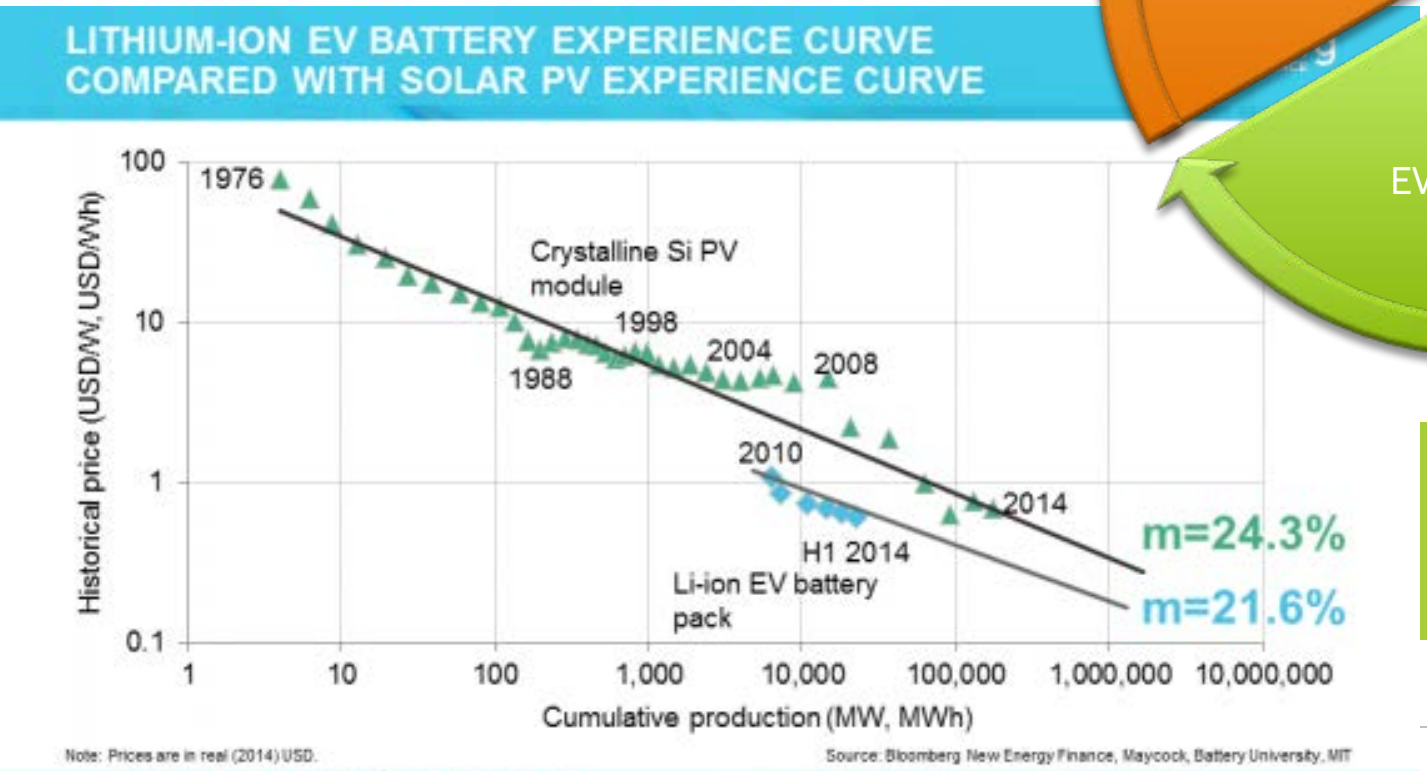
Massachusetts State of Charge Report, 2016

Can also do this with controllable loads (commonly thermal storage)

Trends Driving Energy Storage







Prediction: Cost will fall by 70% over next 15 years.

Energy storage: Good, Bad, Ugly

The Good

Can solve many of the grid's problems

load leveling | frequency regulation | contingency reserves | firm capacity

The Bad

Expensive

Adds Nothing

The Ugly

Carbon Intensive (Manufacture | round trip efficiency<1)

Dangerous

Grid Flexibility First

A **high flexibility grid** can achieve the same renewable energy penetration with **half the energy storage** as a low flexibility grid.

Source: Denholm et al. [2016]

1. **Reduced minimum generation levels**
2. **Increased export capacity**
3. **Expanded demand Flexibility, and**
4. **Optimized charging of electric vehicles**

Source:

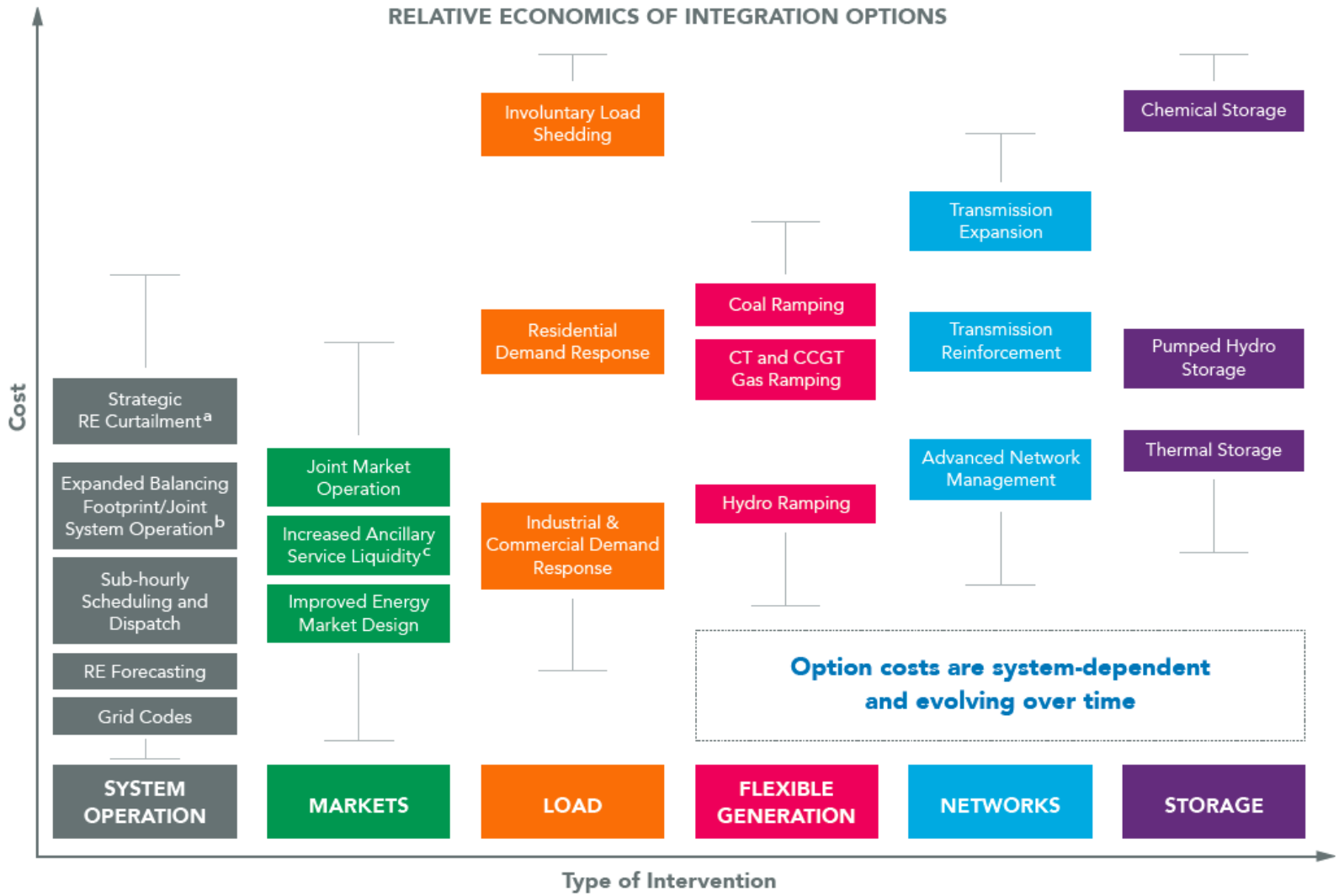
Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California

Paul Denholm and Robert Margolis

National Renewable Energy Laboratory (NREL)

August, 2016

Flexibility

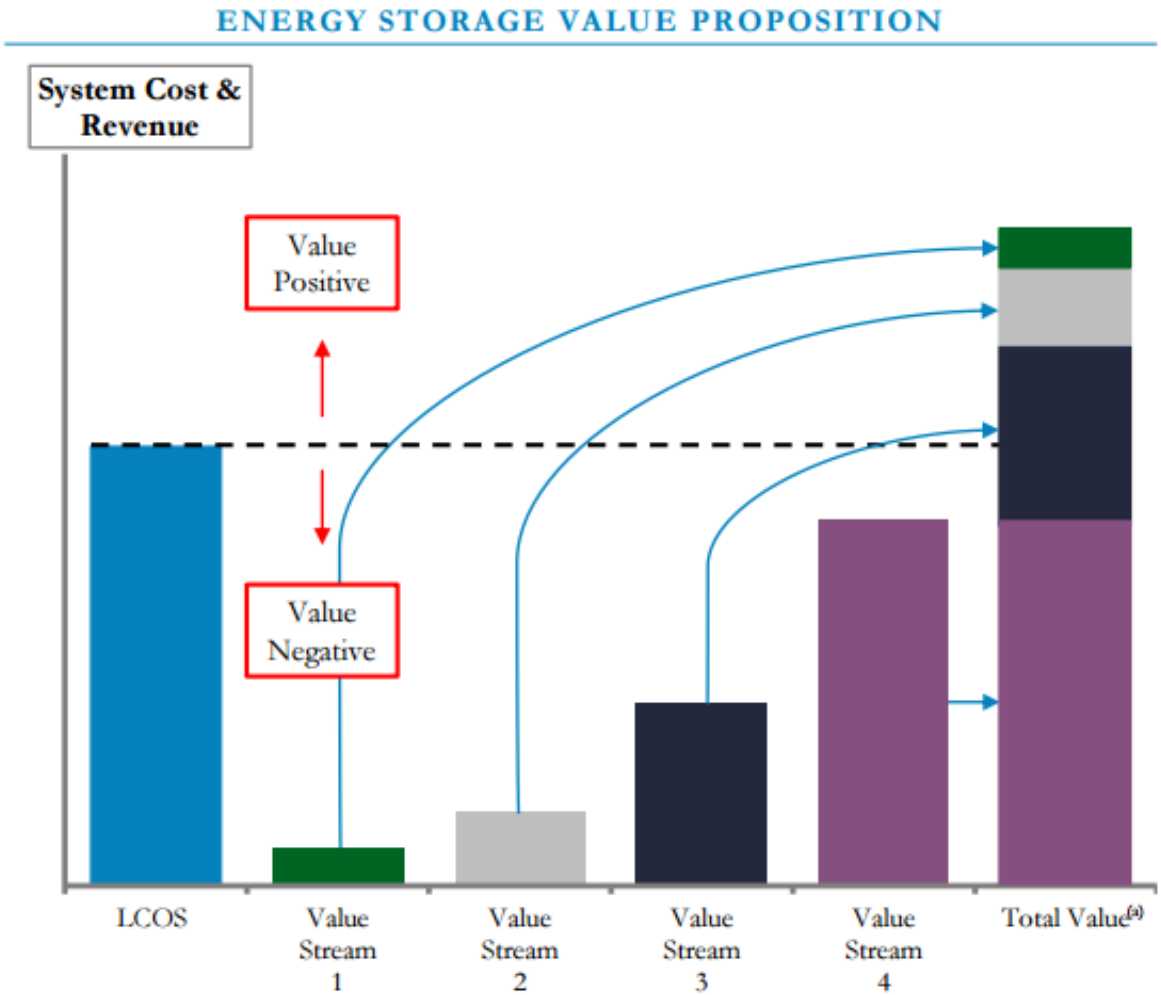


Relative Economics of Integration Options [Cochran et al., 2014]

Stacked Value of Energy Storage

Value Stream Examples

- Frequency Regulation
- Demand Response
- Demand Charge Management



Spirae - Deployed Wave Systems

Customer	Location	Assets	Delivery	Objective
Green Mountain Power	Vermont	Dynapower Battery Energy Storage (2 MW/1 MWh Li Ion; 2 MW/1.2 MWh Lead Acid) SolarEdge/Tesla – Behind the Meter	2016-2017	Peak Management
Investor Owned Utility	California	Grid-scale ABB/Saft (x2) 1 MW/3 MWh Parker/Saft 0.5 MW/1.5 MWh Greensmith/ABB/Samsung Greensmith/Satcon/Winston S&C/Dow Kokam Community Storage S&C 25 kW/75 kWh	2016	Resilience Microgrid
Avista Utility	Washington	UET flow battery 1 MW/4 MW	2017	Economic Optimization
Flathead Electric Co-op	Montana	800 Electric Water Heaters, Aclara Communications	2015	Peak Management
OEM	Illinois	DEIF AGC-4 (genset control) EMCP 4.4 (genset control) ISO Switchgear (genset switchgear) SMA Tripower 24000TL-US (PV inverter) BDP-250 (ESS inverter)	2016	Remote Microgrid

NY REV	Aliso Canyon	FERC
ConEdison 300 homes in Brooklyn and Queens Virtual Power Plant Leased solar panels and lithium ion batteries Peak shaving and frequency regulation	**Southern California Edison** **San Diego Gas and Electric** 60 MW utility scale storage SCE – 20 MW (80 MWh) SDG&E – 37.5 MW (150 MWh) Fast – 6 months or less	**PJM** Front of the meter Interim cap – Regulation D 2017 – 100 MW Frequency Regulation
De-Carbonization **Grid Modernization**	**Loss of resource – natural gas supply**	**Market Demand**

Infrastructure Deferral

New York (Con Ed)

- ~~$1.2B substation upgrade needed~~
- Energy efficiency
- Distributed generation
- Demand response
- Energy storage

$200 M

$1 Billion Saved AND can integrate more renewables

Grid Flexibility for a Tiny Grid

Ta'u, Samoa – 14 MW Solar – 6 MWh Energy Storage – 100% Renewable

Good Policy Wanted

Utility DIVE Home Events Library Jobs Viewpoints

Generation T&D Solar Storage Demand Response Distributed Energy Regs

BRIEF

FERC seeks comment on new rules for energy storage in wholesale power markets

To Those Who Have Inspired, Encouraged, Assisted, Supported, Coached, and just plain beat things into my head…

My Parents

Dr. Franz Brotzen

Dr. Few

Dr. Jane Davidson

Jeff Miller

Sue Reilly

Dr. Maury Albertson

Thank You!

Peggy Plate

Dr. Byron Winn

Judy Dorsey

Jim Welch

Dan Bihn

Randy Udall

Chris Cook

Jigar Shah

Randy Gee

Kelly Beninga

Sunil Cherian

Bill Becker

My Daughters

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