The Value of Energy Storage

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Steven Rupp

BUILDING A WORLD OF DIFFERENCE®

BLACK & VEATCH

Solving the World's Complex Challenges in These Markets

Energy
Indonesia

Water
Hong Kong SAR

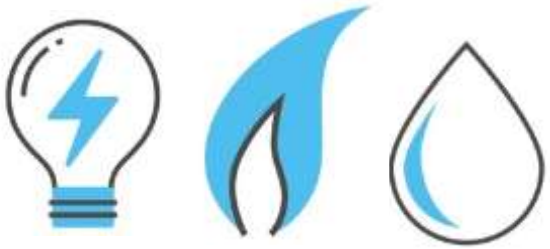
Telecommunications
California, USA

Security
Armenia

Management Consulting
Oklahoma, USA

Environmental
Scotland, UK

Black & Veatch Today



Consulting Markets Served

in the power, oil & gas and water industries.

11,000+ Professionals

in 110+ offices.

$3.4 Billion

revenue in 2017.

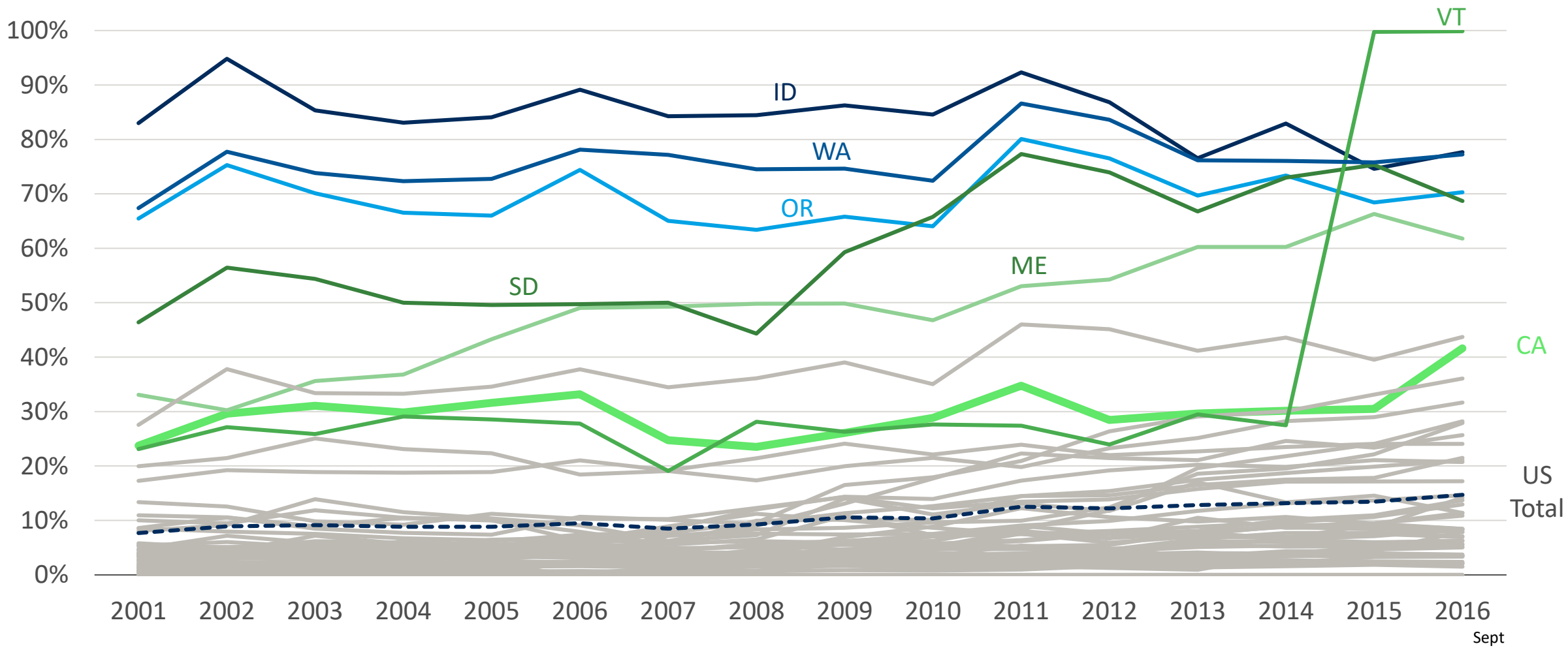
7,000 Active Projects

worldwide on six continents.

100+ Years

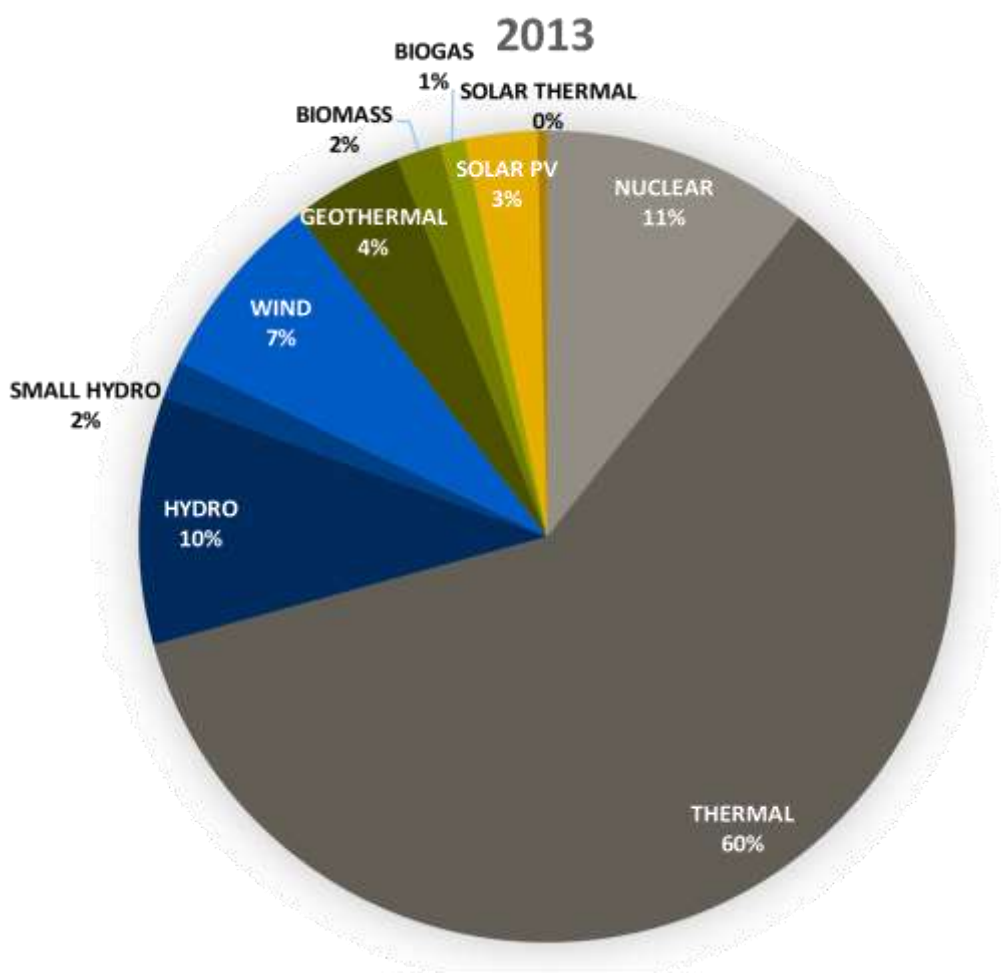
experience. Founded in 1915.

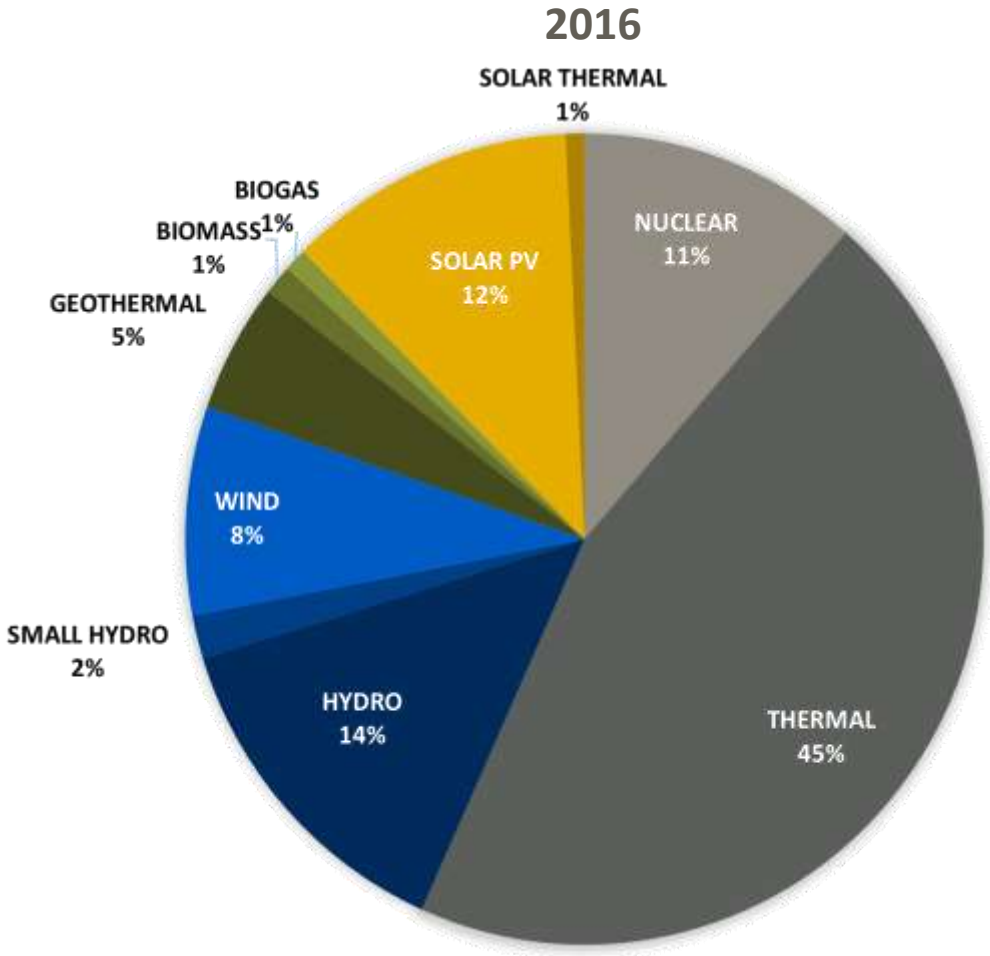
Fraction of State Generation from Renewable Energy Including Hydro



Source: EIA Electric Power Monthly, Data through September 2016. Accessed November 30, 2016.
https://www.eia.gov/electricity/monthly/

California In-state Generation (CAISO)





43% of in-state CAISO generation came from renewable sources in 2016

Source: B&V analysis of CAISO hourly generator output files from 12/2012-12/2016

Value for Providers

- Firming of renewables
- System flexibility
- Transmission and distribution deferral
- Ancillary services
- Demand response
- Energy arbitrage

Value for the End User

- Reducing electric bill
  - Demand charges
  - Time of use rates
- Participate in demand response programs
- Participate in energy arbitrage
- Provide emergency backup power
- Improve power quality

Societal Benefits

- Reduced emissions from generation
- Greater adoption of renewable energy resources
- No local air quality impact

Amber Kinetics

West Boylston, MA Flywheel Project

- West Boylston Municipal Light Plant
- 128 kW/512 kWh (16, 32 kWh flywheel units)
- Coupled with 370 kW solar energy system
- Energy arbitrage
- Transmission cost reduction

Photo Credit: Amber Kinetics

EDF McHenry 19.8MW/7.865MWh ESS

Capacity	19.8MW/7.865MWh
Completion	2016.1
Location	Chicago, USA
Owner	EDF
Application	Frequency regulation

Photo Credit: BYD America

Lockheed Martin

Solar Plus Storage in North Carolina

- 12 MWh Li-ion ESS
- Peak demand reduction
- Solar Firming

ESS in Ontario, Canada

- 8.5-MW Li-ion ESS
- Peak demand reduction

Photo Credit: Lockheed Martin

Primus Power

Marine Corps Air Station Miramar

- 280 kW / 1 MWh Zinc Iron Redox Flow Battery
- Microgrid
- Demand charge reduction
- Emergency power

Photo Credit: Primus Power

VRB Energy (Pu Neng Energy)

Zhangbei, China

- 2 MW / 8MWH Vanadium Redox Flow Battery.
- Connected to 500 MW solar – wind system
- Renewable smoothing
- Frequency regulation
- Peak shifting

Photo Credit: VRB Energy

Criteria for Adoption

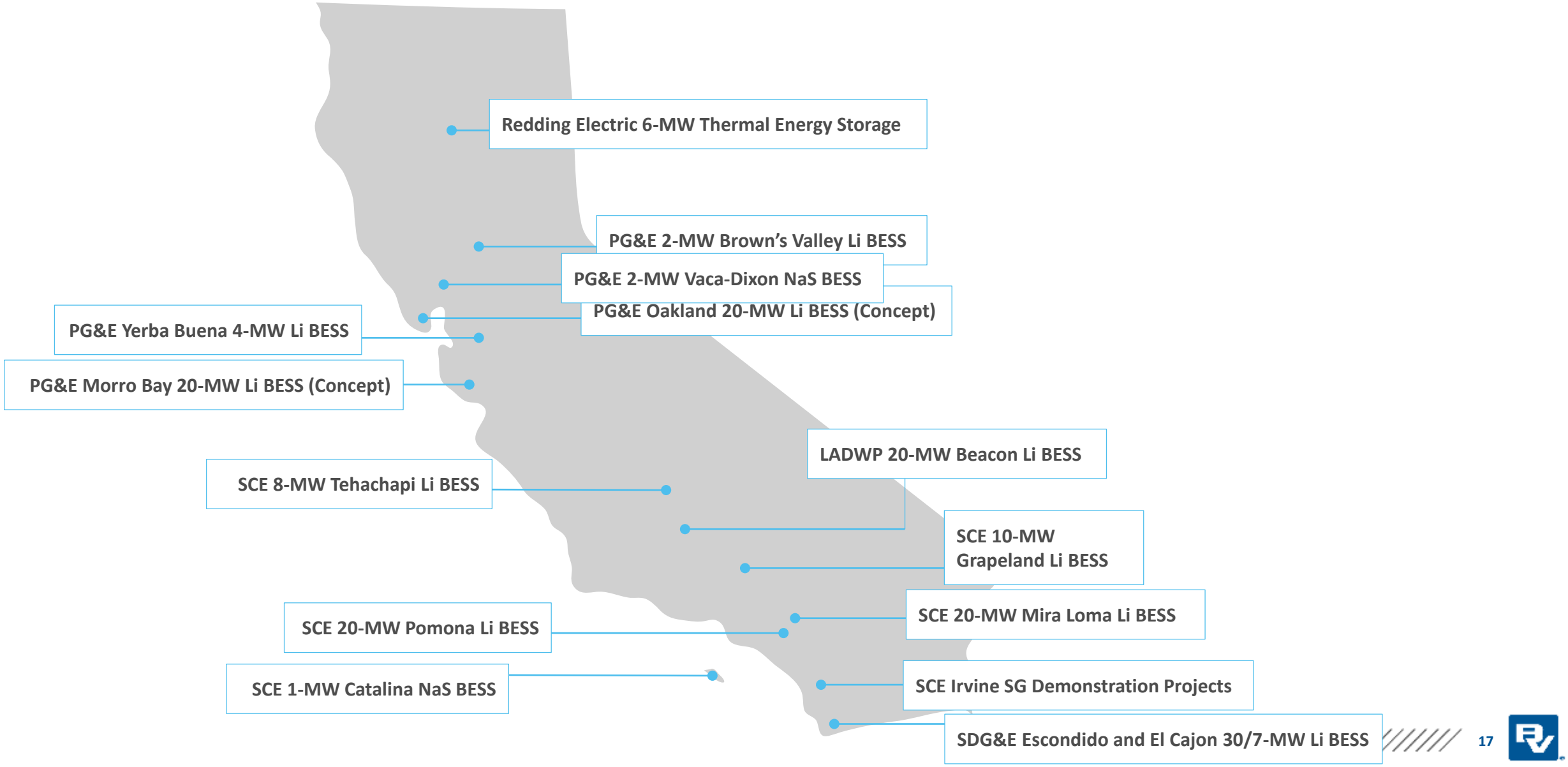
- Reliability (proven technology)
- Ability to Service & Warrant (established manufacturers)
- Safety (Low/No risk of fire, chemical spill)
- Compelling Economics over lifecycle
- Ease of integration with existing equipment/system

Energy Storage in California

California Energy Storage Snapshot

- AB327 requires utilities to develop Distribution Resource Plans
- AB2514 requires utilities to develop 1,325-MW of energy storage by 2024
- CPUC Permanent Load Shifting and Self Generation incentives for customer-sited energy storage projects
- AB2868 requires utilities to invest in an additional 500-MW of distributed energy storage
- Electric Program Invested Charge (EPIC) Demonstrations Programs

California Energy Storage Snapshot of Recent Projects



PG&E Energy Storage Demonstration Projects

Vaca-Dixon NaS BESS

- 2-MW / 14-MWh Sodium-Sulfur Batteries
- Transmission Grid Connected
- CAISO Dispatched
- REG-UP/DN, Spinning Reserve, Voltage Regulation and Solar Firming

Yerba Buena NaS BESS

- 4-MW / 48-MWh Sodium-Sulfur Batteries
- Distribution Grid Connected
- Customer reliability, peak load reduction and CAISO ancillary services

Photo Credit: Pacific Gas and Electric Company

SDG&E Energy Storage Projects

Escondido BESS

- 30-MW / 120-MWh Li Ion Batteries
- Transmission Grid Connected
- CAISO Dispatched
- REG-UP/DN, Spinning Reserve, Voltage Regulation and Solar Firming

El Cajon BESS

- 7.5-MW / 30-MWh Li Ion Batteries
- Distribution Grid Connected
- Customer reliability, peak load reduction and CAISO ancillary services

Photo Credit: San Diego Gas and Electric Company

Thank You

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