

# Opportunities and Risks for Energy Storage

Tim Hemig, SVP Strategic Development

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North American Power Credit Organization  
March 2019



# Energy Storage: The Handy Grid Tool

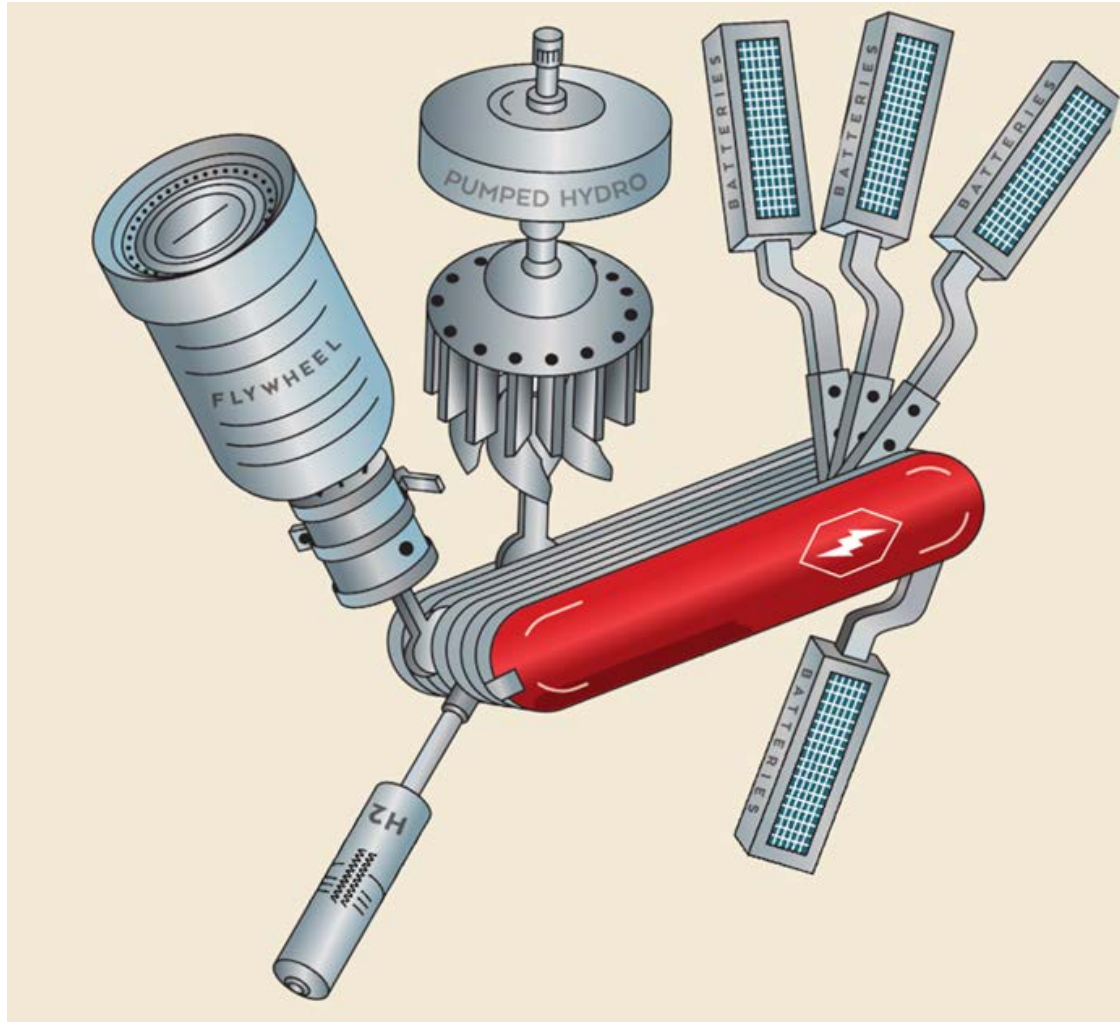
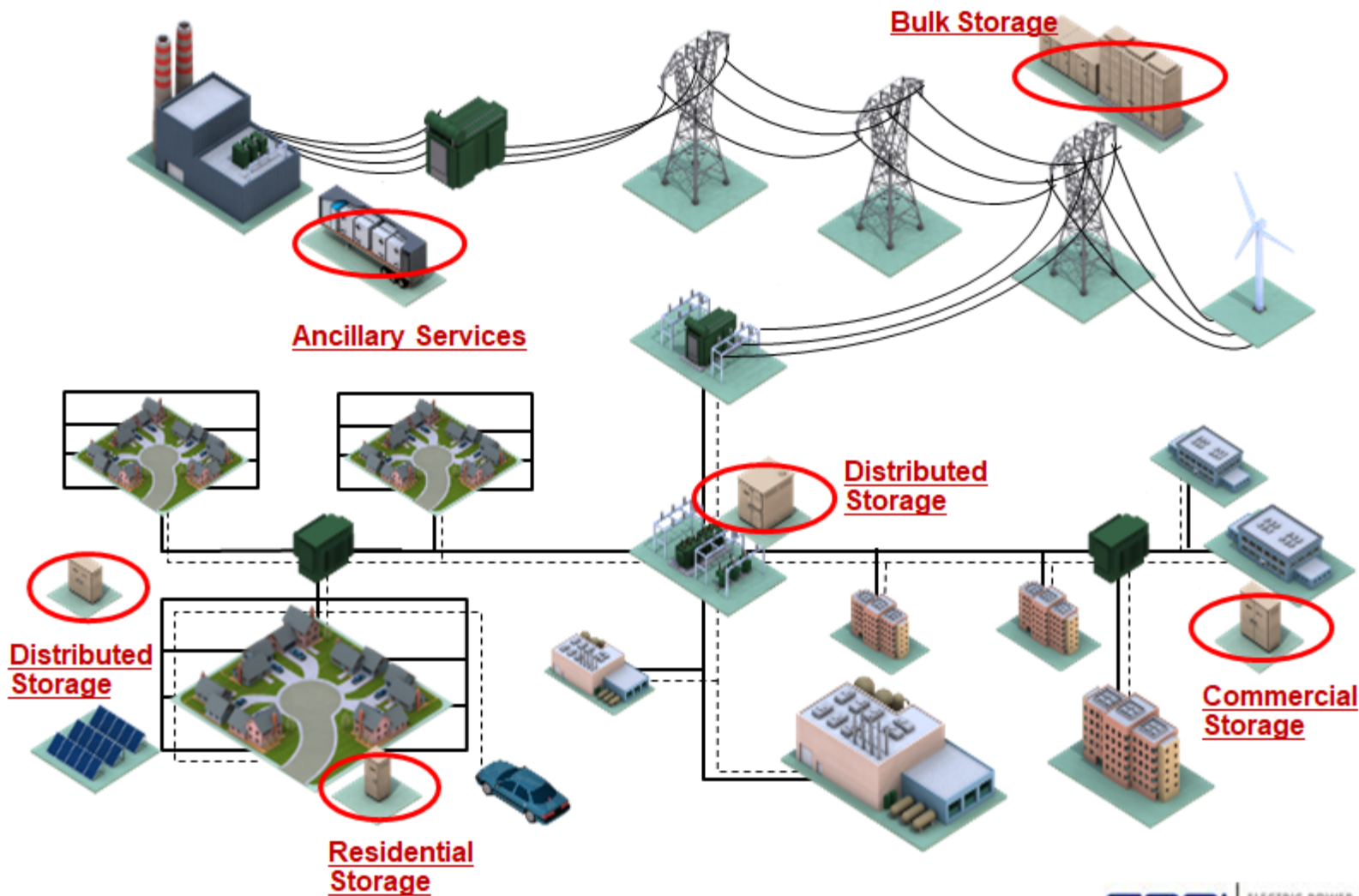


Image Credit: California Municipal Utilities Association, *California Water And Power*, Winter 2019



# Tenaska Overview

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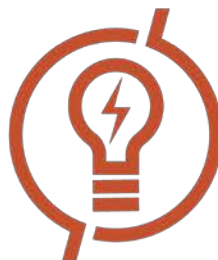


## Energy Marketing

Natural Gas  
Electric Power

### BUSINESS UNITS

- Tenaska Marketing Ventures
- Tenaska Marketing Canada
- Tenaska Gas Storage, LLC
- Tenaska Gas de México
- Tenaska Power Services Co.
- Tenaska Power Canada
- Tenaska Power Management, LLC
- Tenaska Energía de México



## Power Generation

Engineering & Construction Management  
Technology Assessment & Evaluation  
Operations  
Asset Management  
Environmental Services

### BUSINESS UNIT

- Engineering & Operations Group



## Development & Acquisitions

Project Development  
Acquisition & Divestiture  
Asset Optimization  
Capital Formation  
Distributed Solar Investments

### BUSINESS UNITS

- Strategic Development & Acquisitions Group
- Tenaska Capital Management, LLC



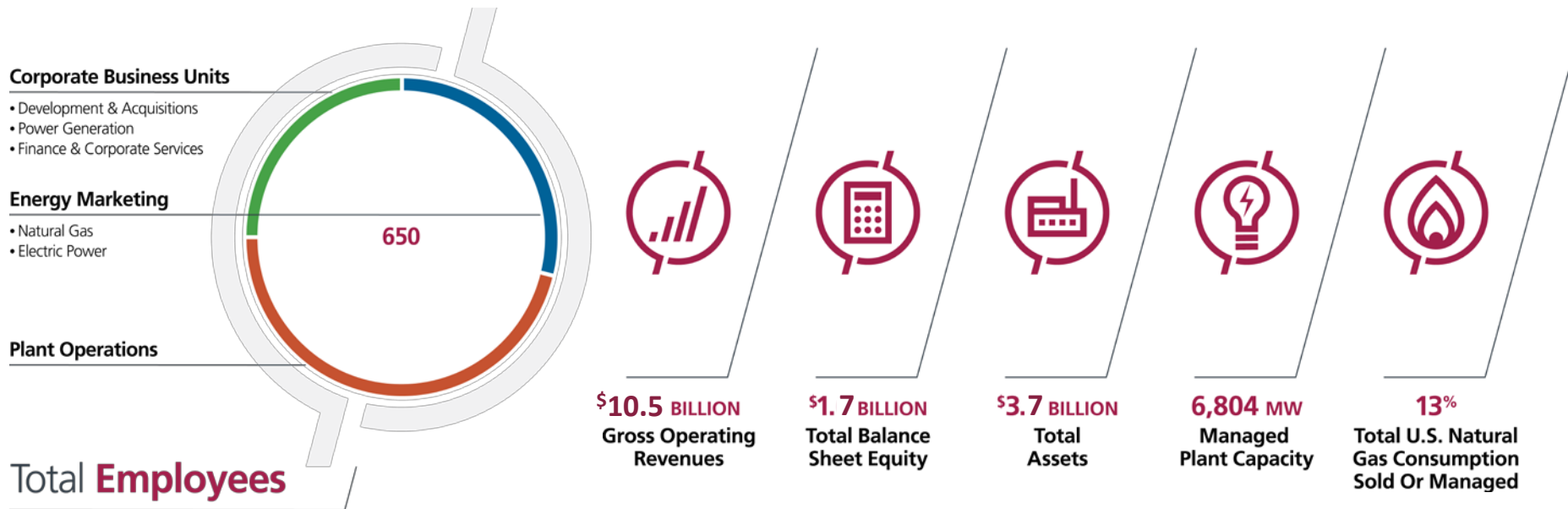
## Finance & Corporate Services

Finance, Tax & Accounting  
Legal  
Government & Public Affairs  
Information Technology  
Human Resources

# Tenaska By The Numbers

***Tenaska has grown over the past 30 years** to be a versatile, yet consistent, energy industry leader*

***These numbers highlight** both our 2017 successes and the tenacious and steady growth of our company*



Reference: Tenaska 2017 Annual Report

# Power Development

10,000 MW

Developed

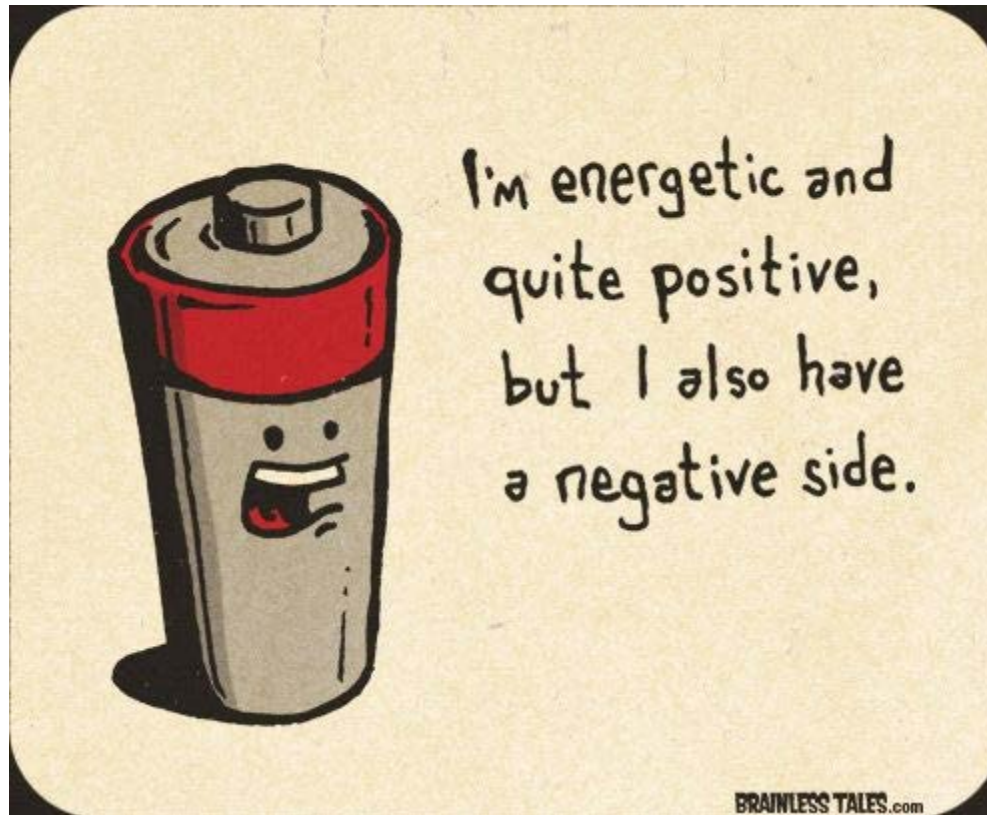


1,500 MW

Advanced  
Development

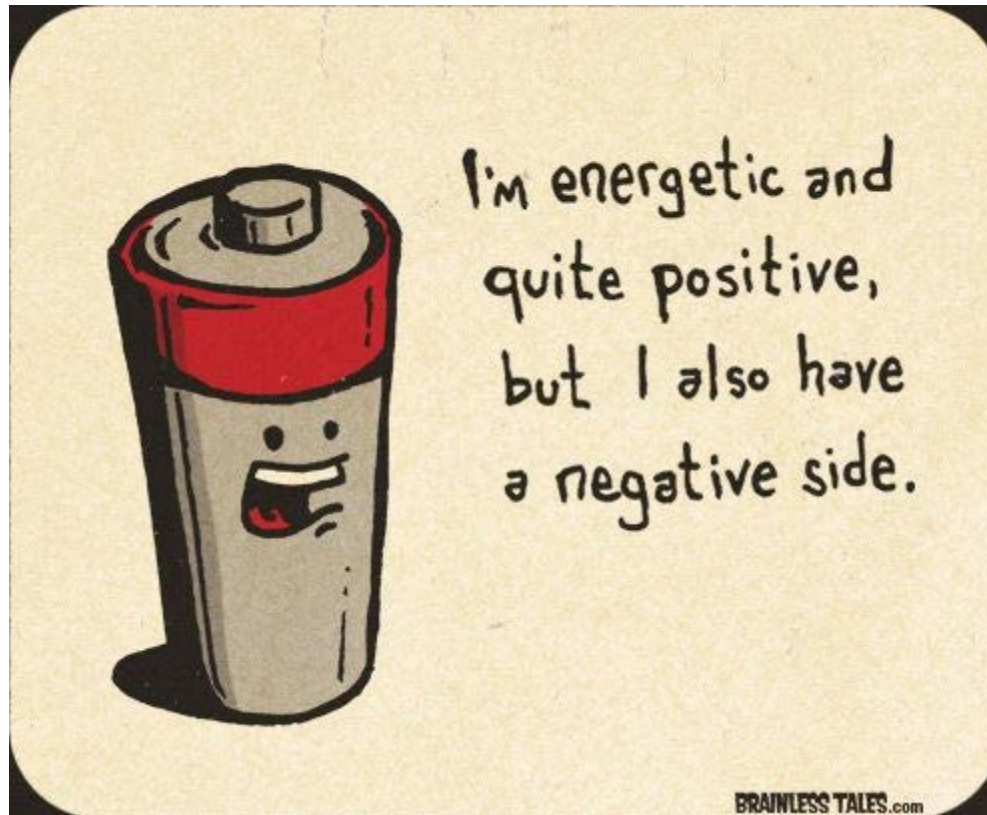


# Energy Storage Systems Explained



### Trivia Question:

Who is credited with the invention of the first battery and when?



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Who is credited with the invention of the first battery and when?

**Alessandro Volta in 1800**

# Energy storage technology classes

**Electro-Chemical**



**Mechanical**



**Bulk Mechanical**



**Thermal**



**Transportation**

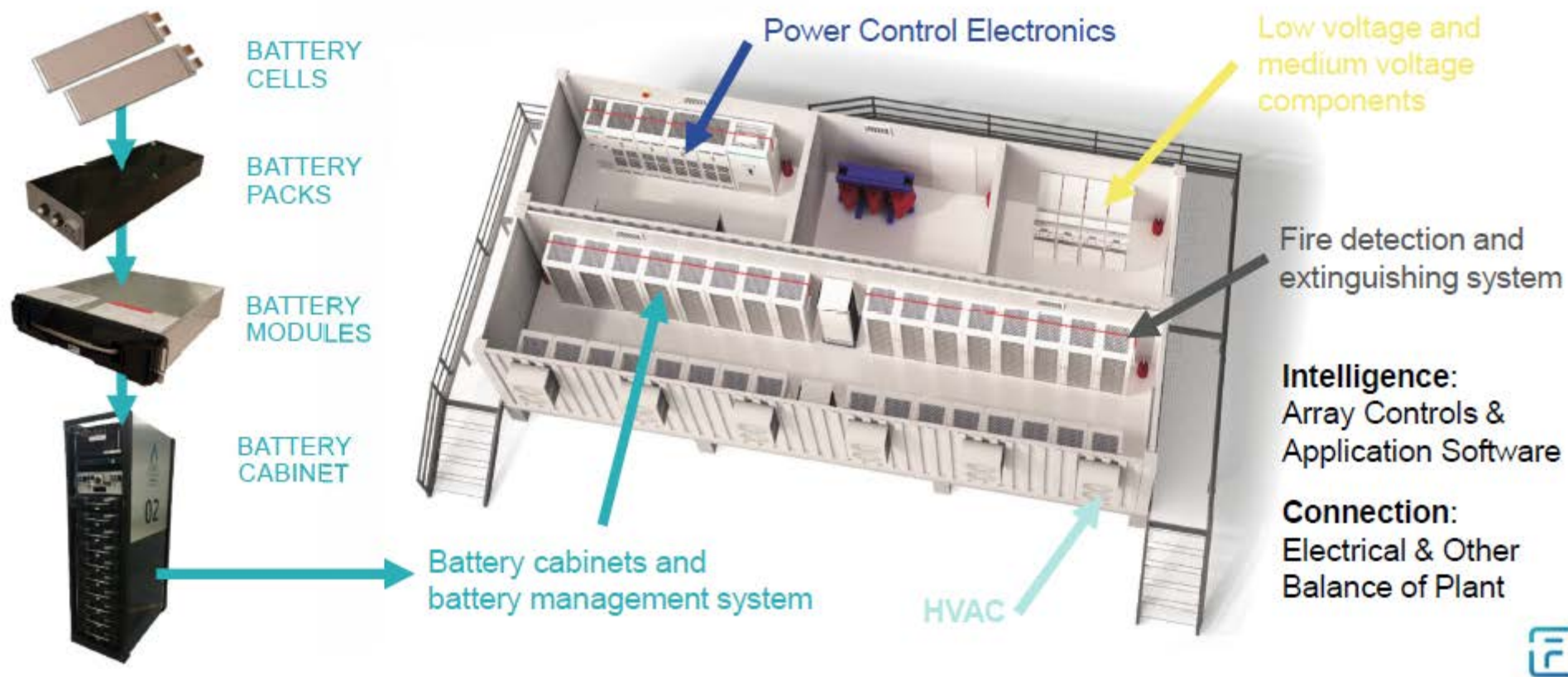


**Bulk Gravitational**



# What is energy storage? Large-scale batteries for industrial applications.

Modular, scalable arrays of proven technologies integrated at utility and industrial scale.

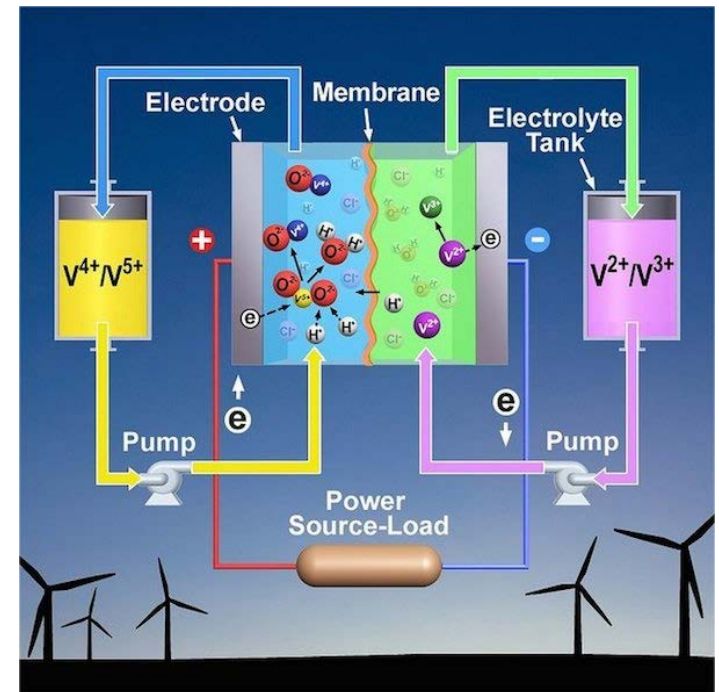


## 30 MW of energy storage for San Diego Gas & Electric, California, United States

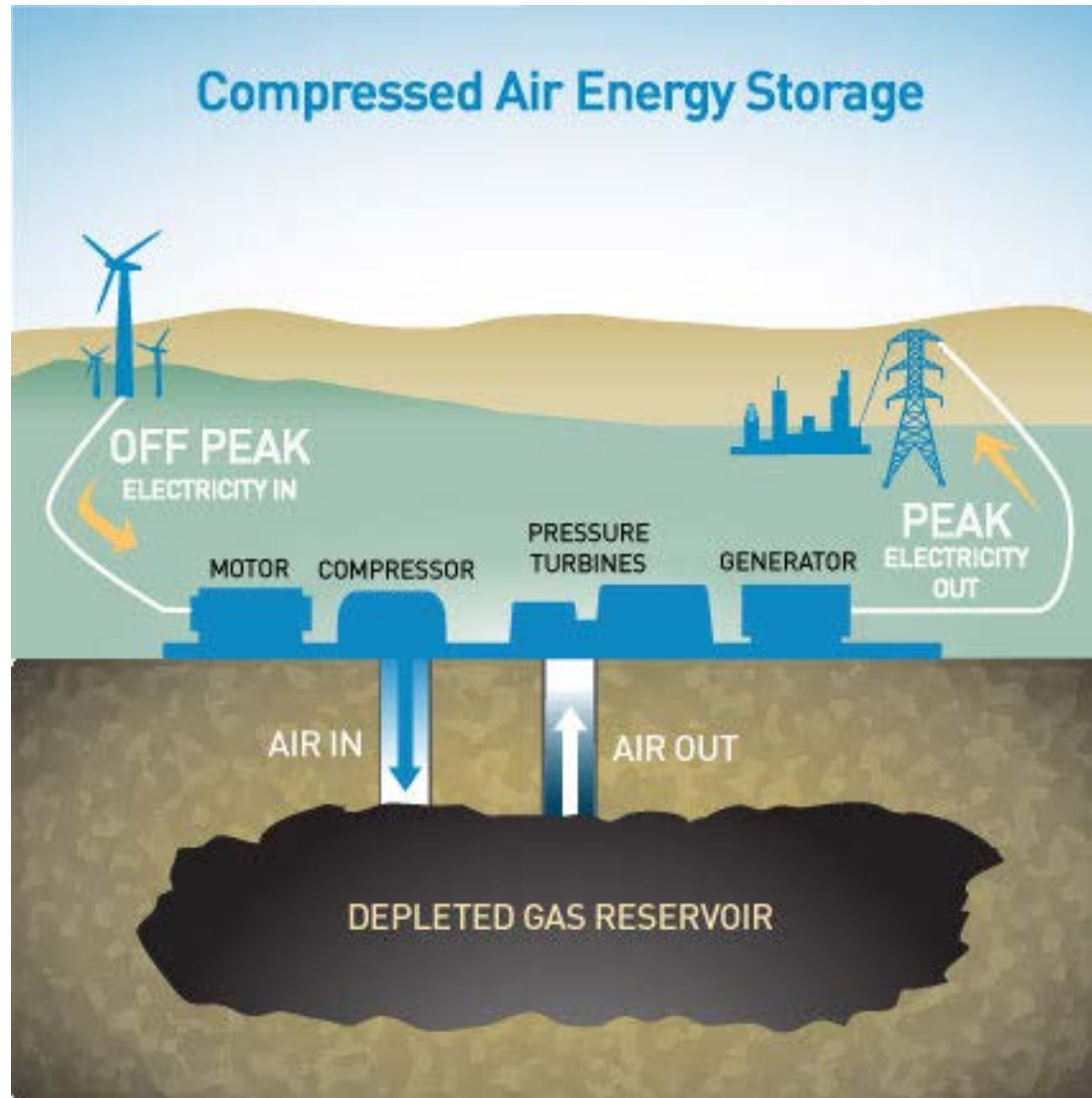
### Largest energy storage project in North America

- 30 MW / 120 MWh
- Contract to online in 6 months
- Sited on 1 acre, where a power plant could not be permitted

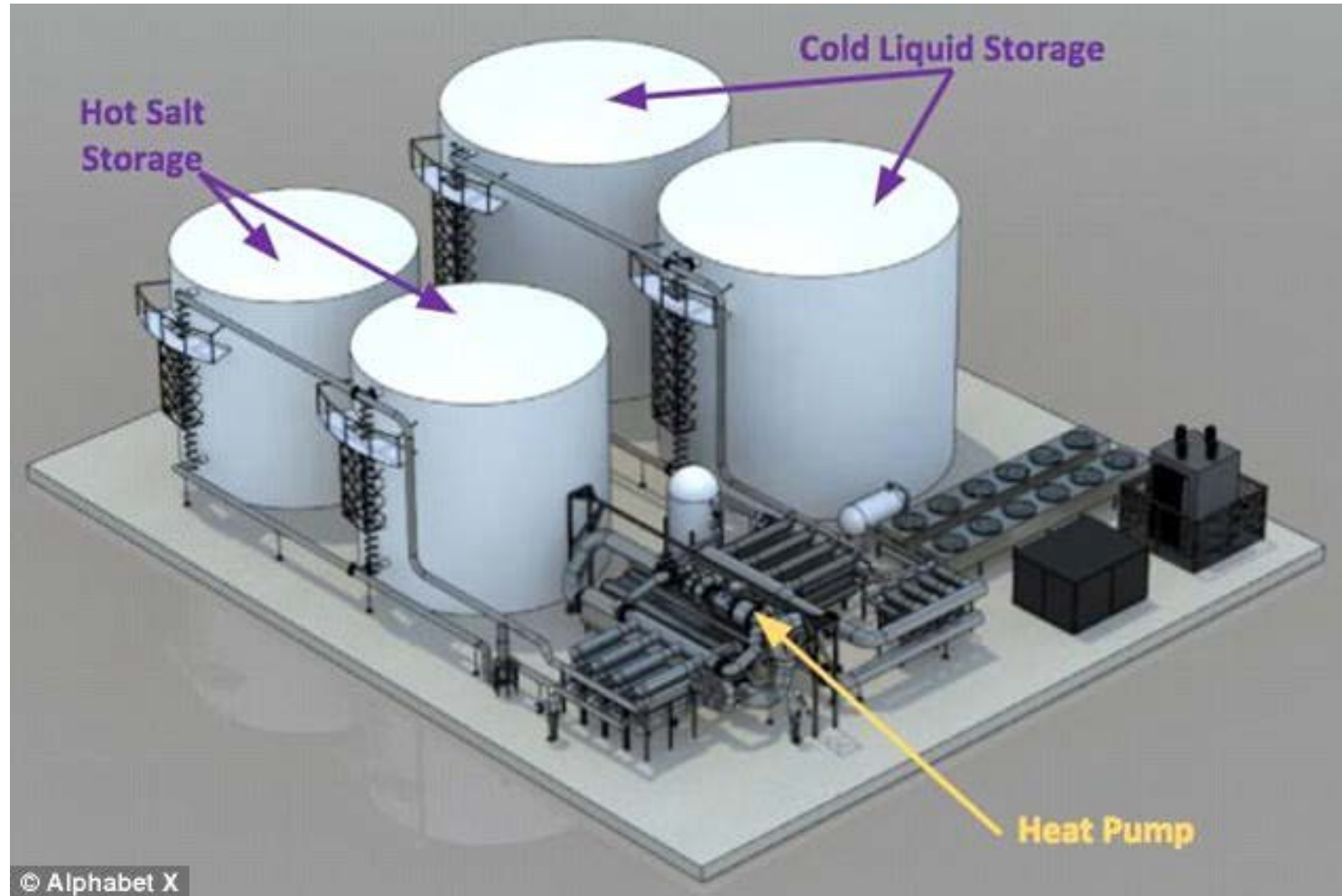
# Flow Batteries



# Compressed Air Energy Storage



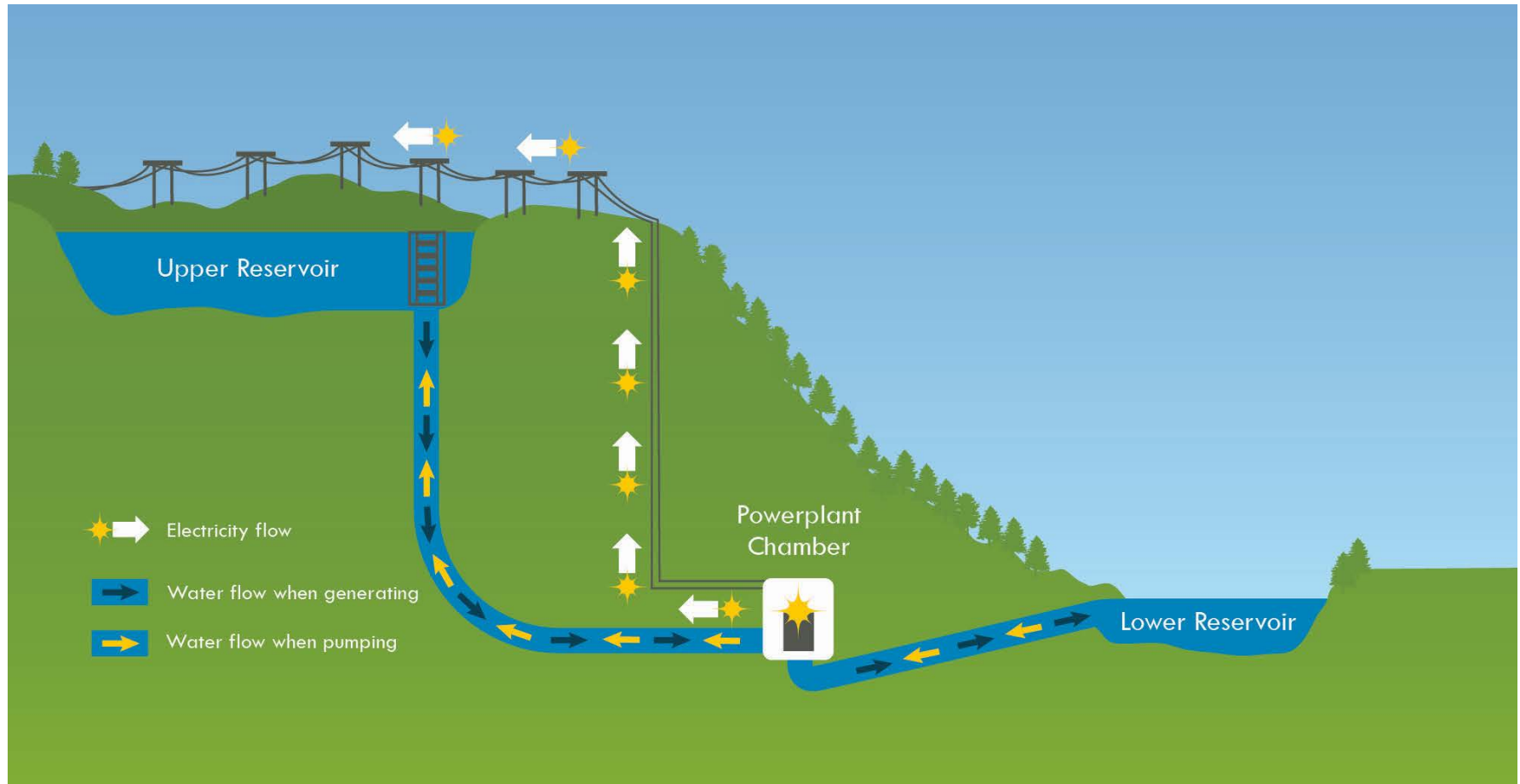
# Thermal Storage



# Flywheel



# Pumped Hydro Storage



# Rail Based Energy Storage



Source: ARES North America website

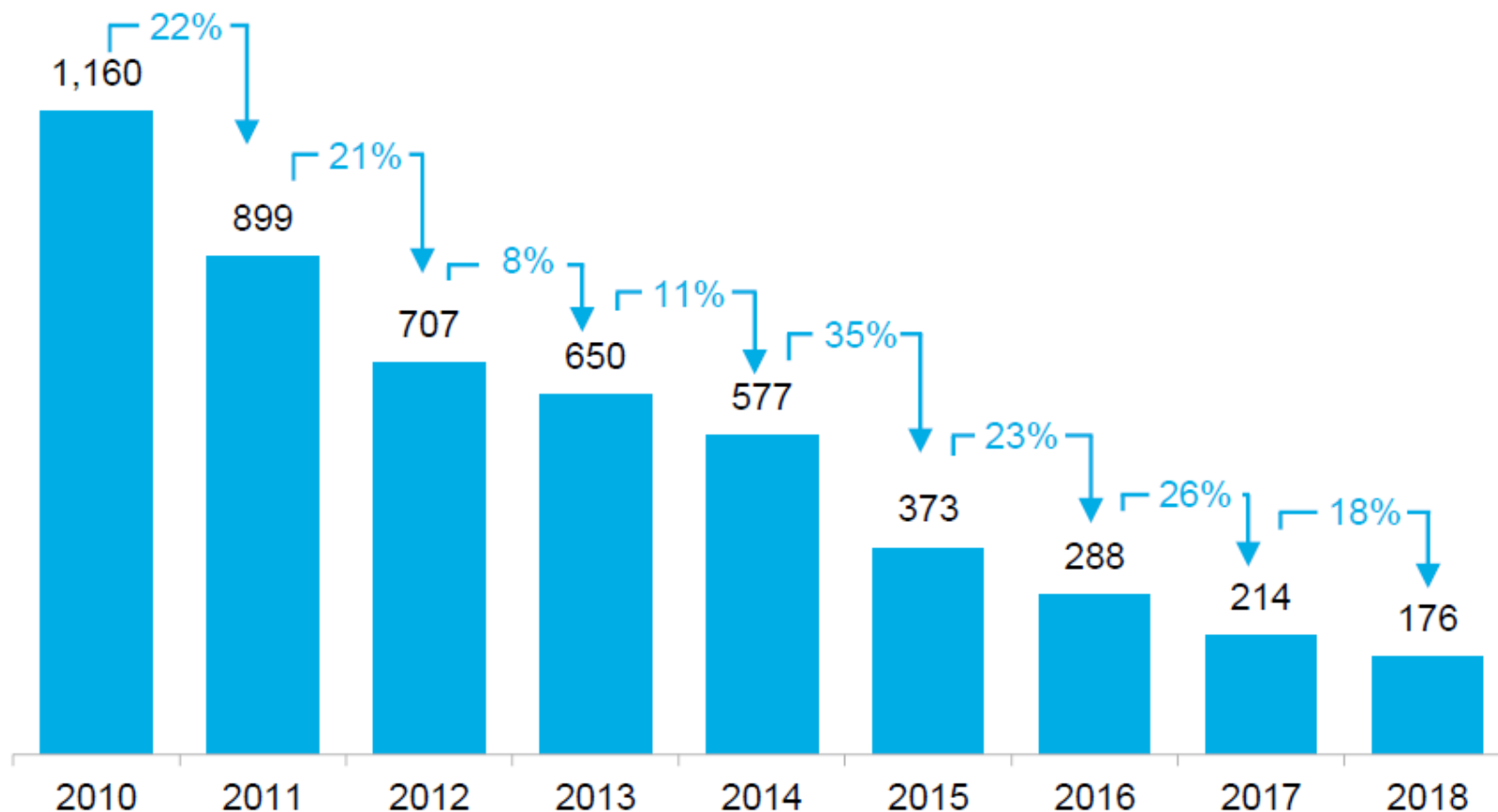
# Other Gravity Based Storage



# Key Drivers of Battery Energy Storage System Costs

# Lithium-ion battery costs

Battery pack price (real 2018 \$/kWh)

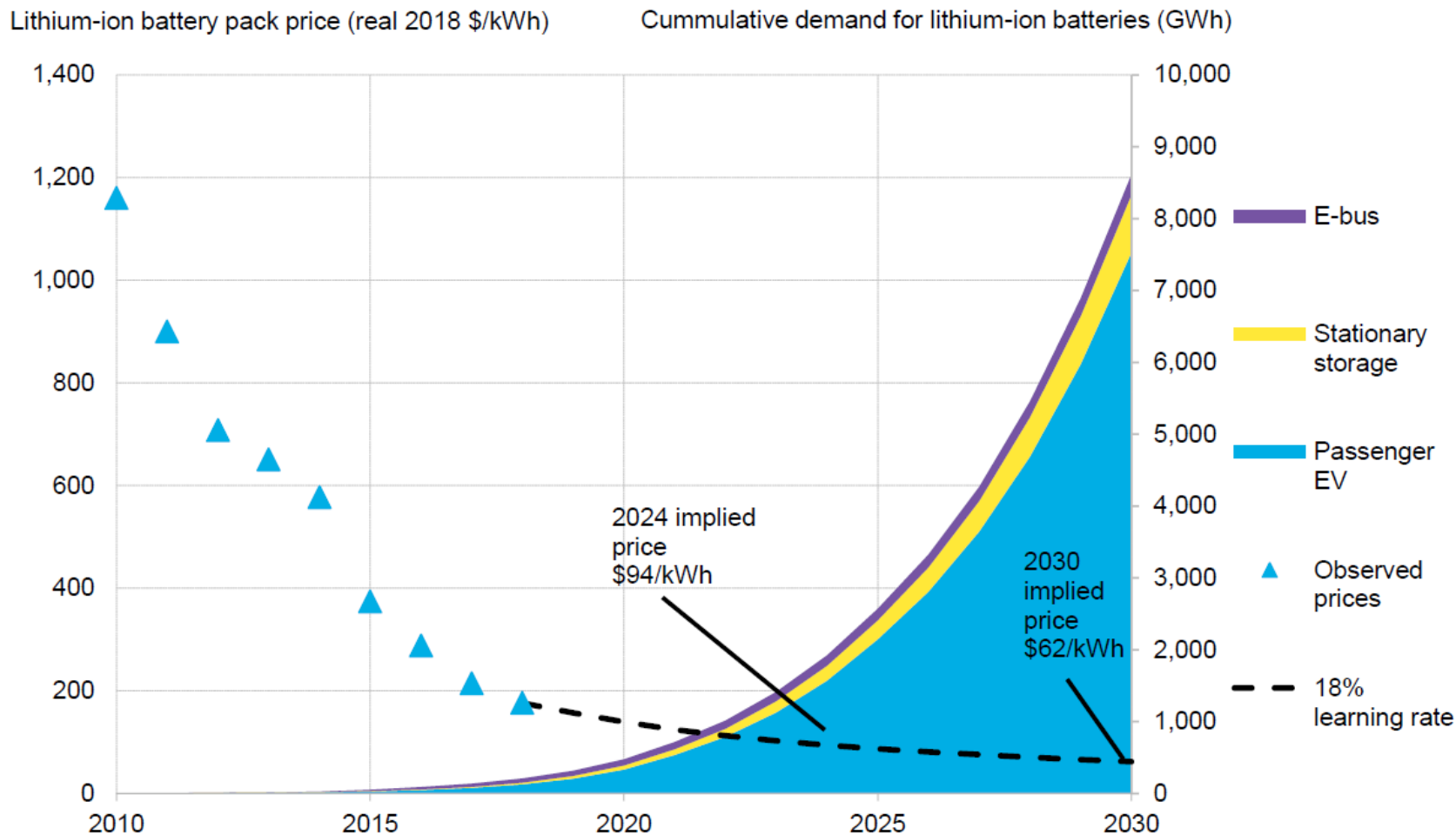


Source: BloombergNEF Note: the data in this chart has been adjusted to be in real 2018 dollars.

# What are the key drivers of cost reduction?

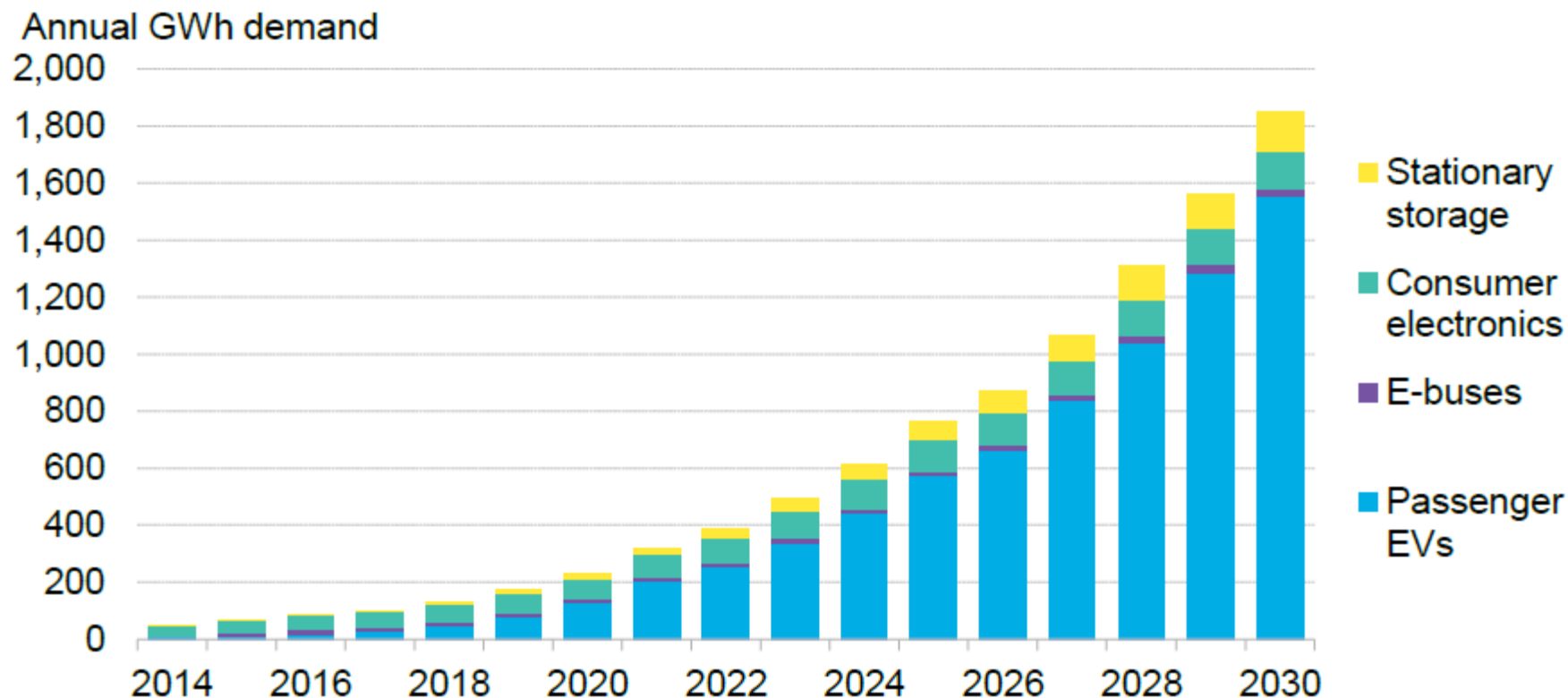
- ▶ Electric Vehicle deployments
- ▶ Battery chemistries and technological advancements
- ▶ Battery form factor and design
- ▶ Economies of scale

# Lithium-ion battery pack price and demand



Source: BloombergNEF Note: The data in this chart has been adjusted to be in real 2018 dollars.

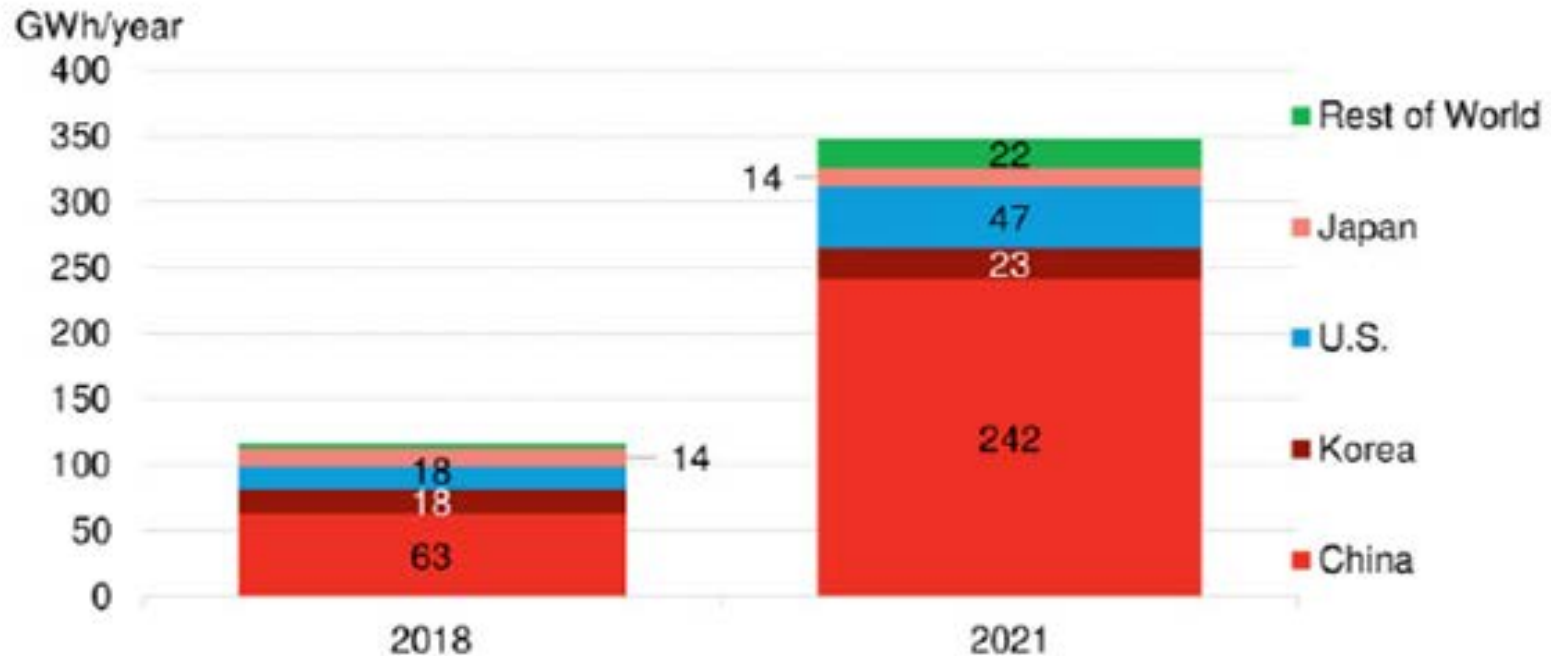
# Battery Demand by Sector



Source: BloombergNEF, Avicenne. Note: consumer electronics demand is sourced from Avicenne, assumes all stationary storage in lithium-ion based

# Manufacturing Capacity is Growing

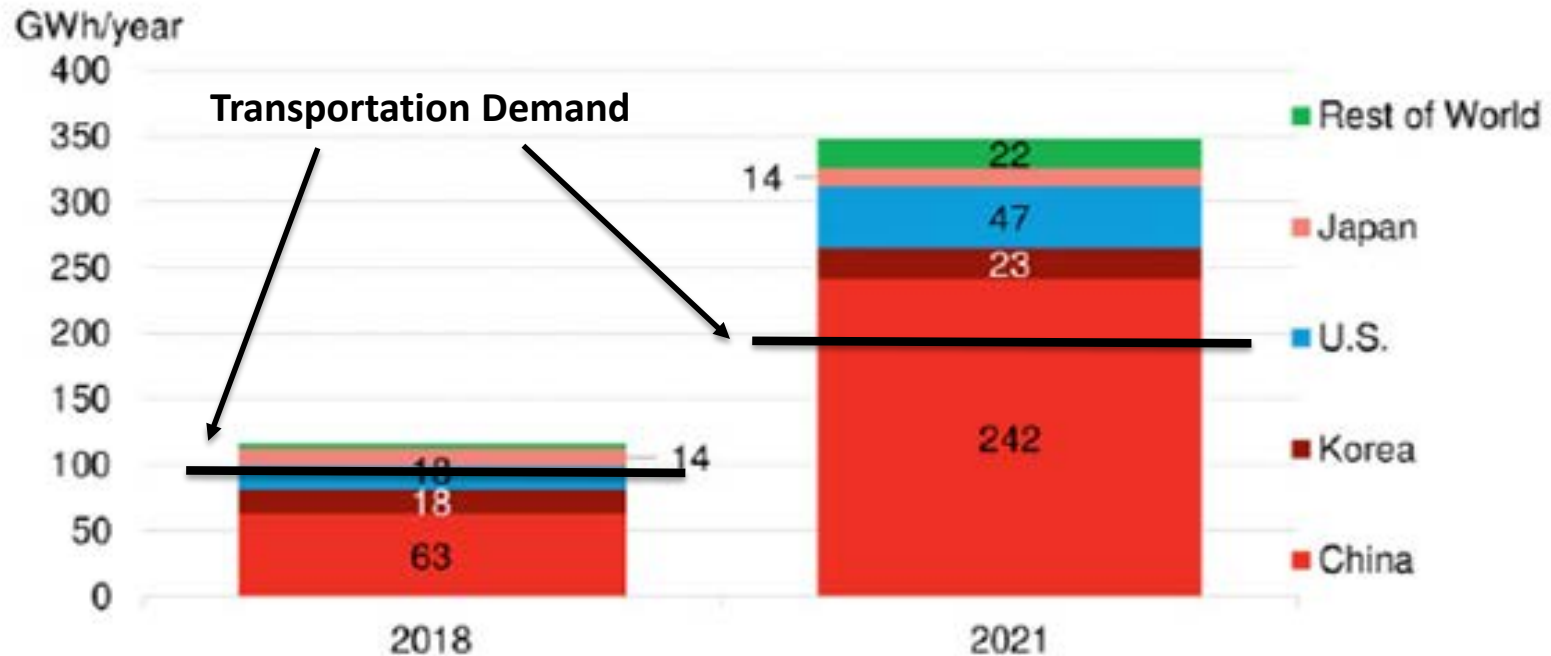
Figure 1: Global lithium-ion battery manufacturing capacity



Source: Bloomberg New Energy Finance. Note: 2021 values based on current and announced capacity additions. Excludes consumer electronics batteries

# Manufacturing Capacity is Growing

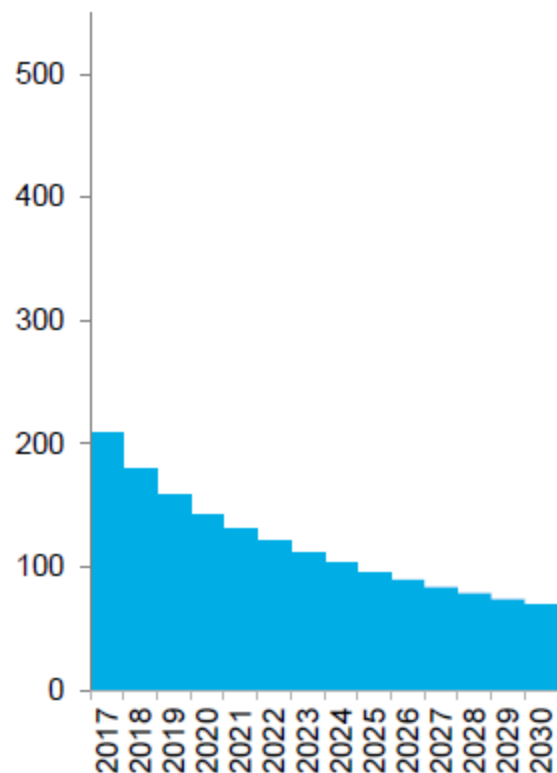
Figure 1: Global lithium-ion battery manufacturing capacity



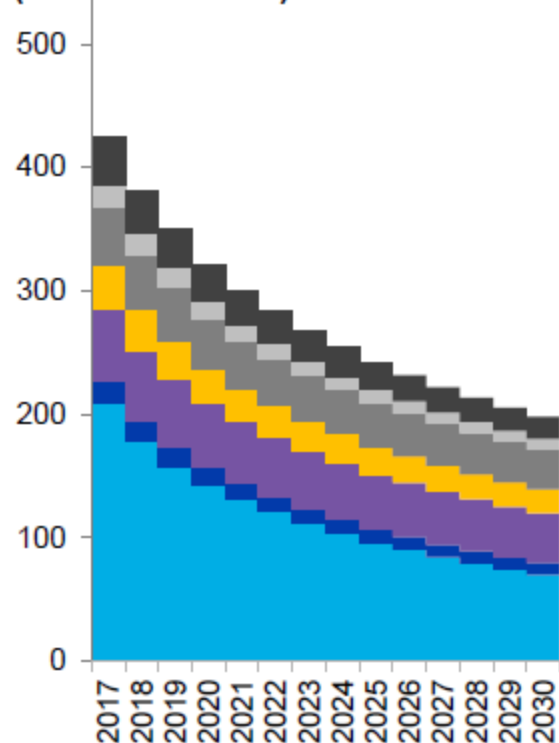
Source: Bloomberg New Energy Finance. Note: 2021 values based on current and announced capacity additions. Excludes consumer electronics batteries

# Large scale battery system forecast (\$/kWh)

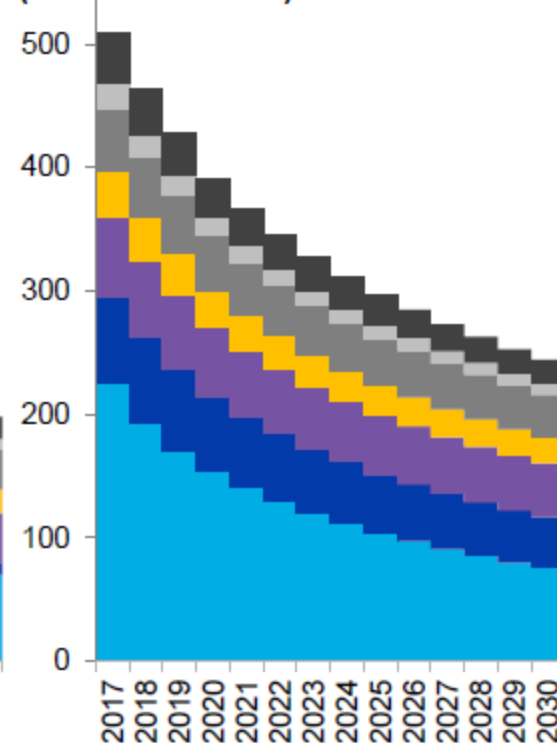
Pack only



Built for resource adequacy  
(4-hour duration)



Built for arbitrage  
(1-hour duration)



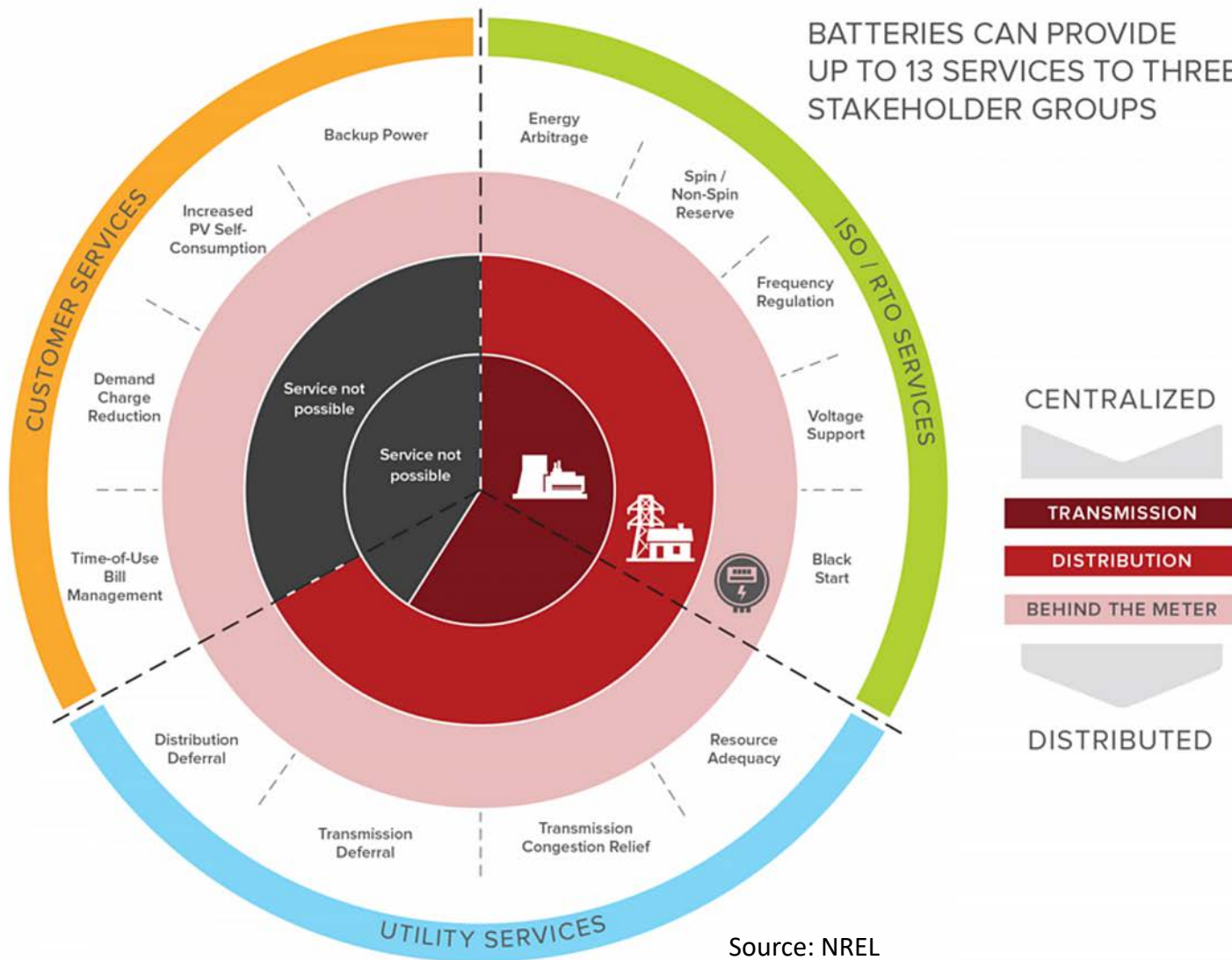
- Developer margin
- Energy Management System
- Developer overheads
- Balance of System
- EPC\*
- PCS
- Battery pack

Source: Bloomberg NEF  
Presentation at CAISO Stakeholder  
Symposium; Oct 17, 2018

# Energy Storage Use Cases

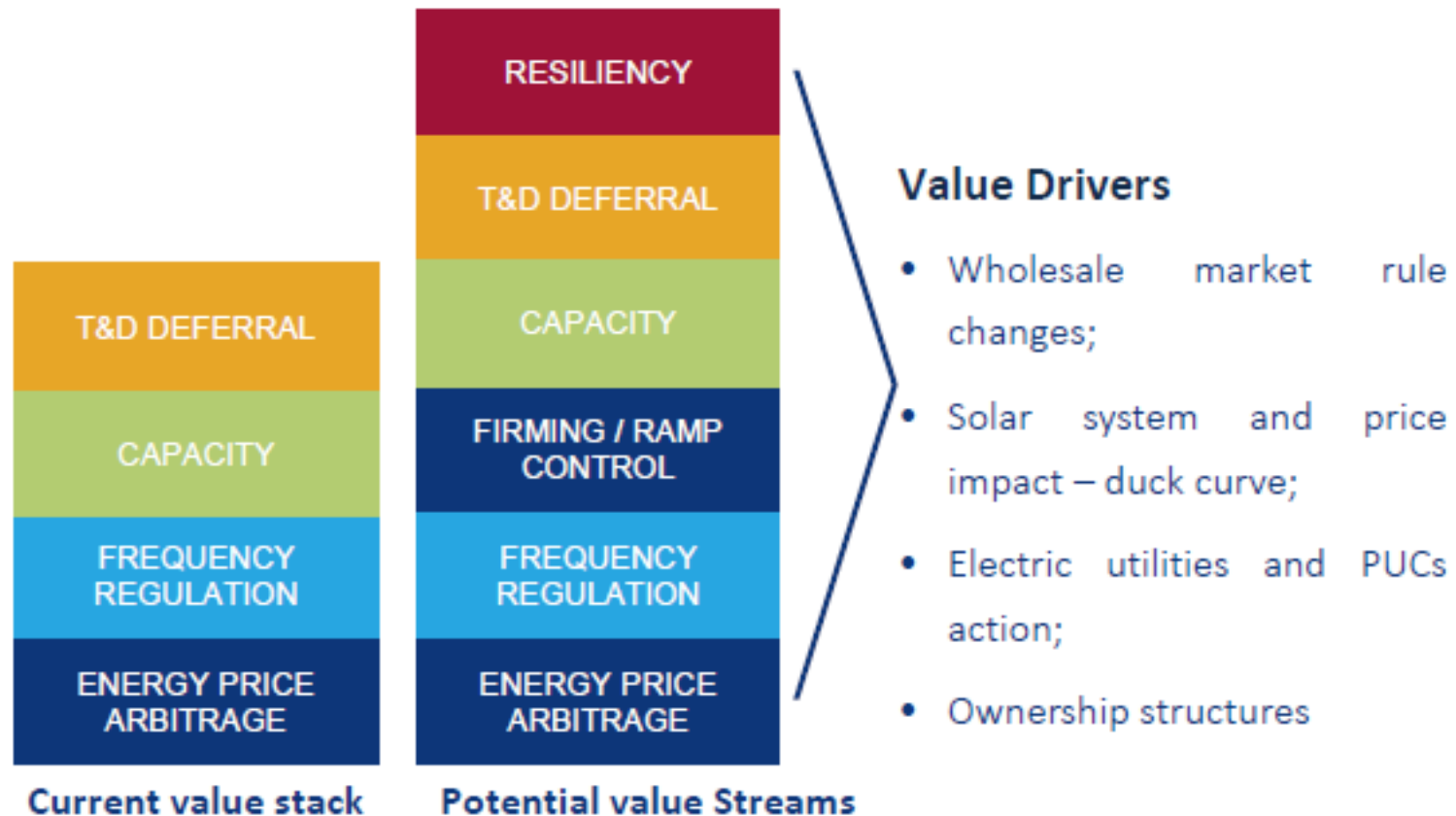
# What does energy storage do?

BATTERIES CAN PROVIDE UP TO 13 SERVICES TO THREE STAKEHOLDER GROUPS



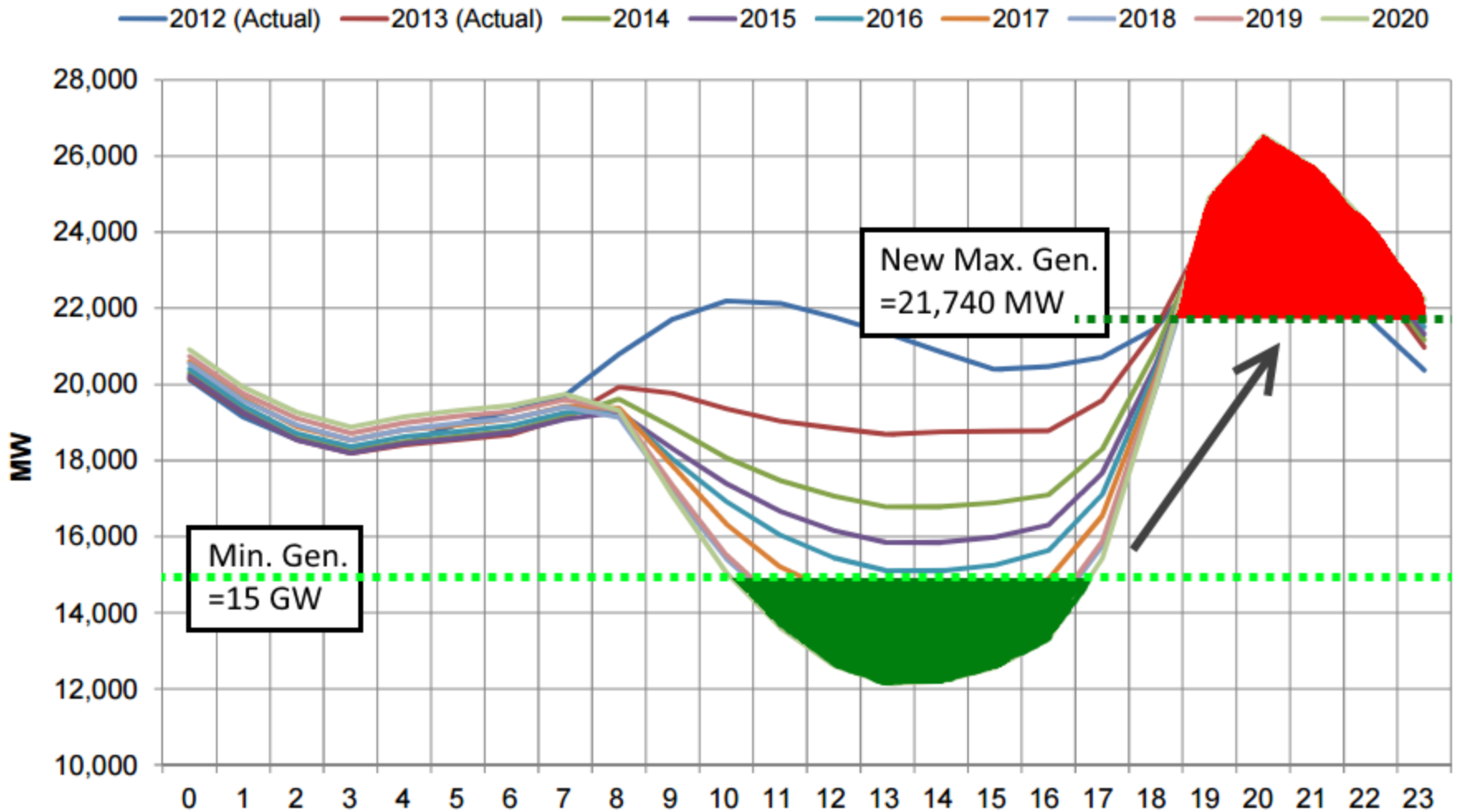
Source: NREL

# Energy Storage Value Streams

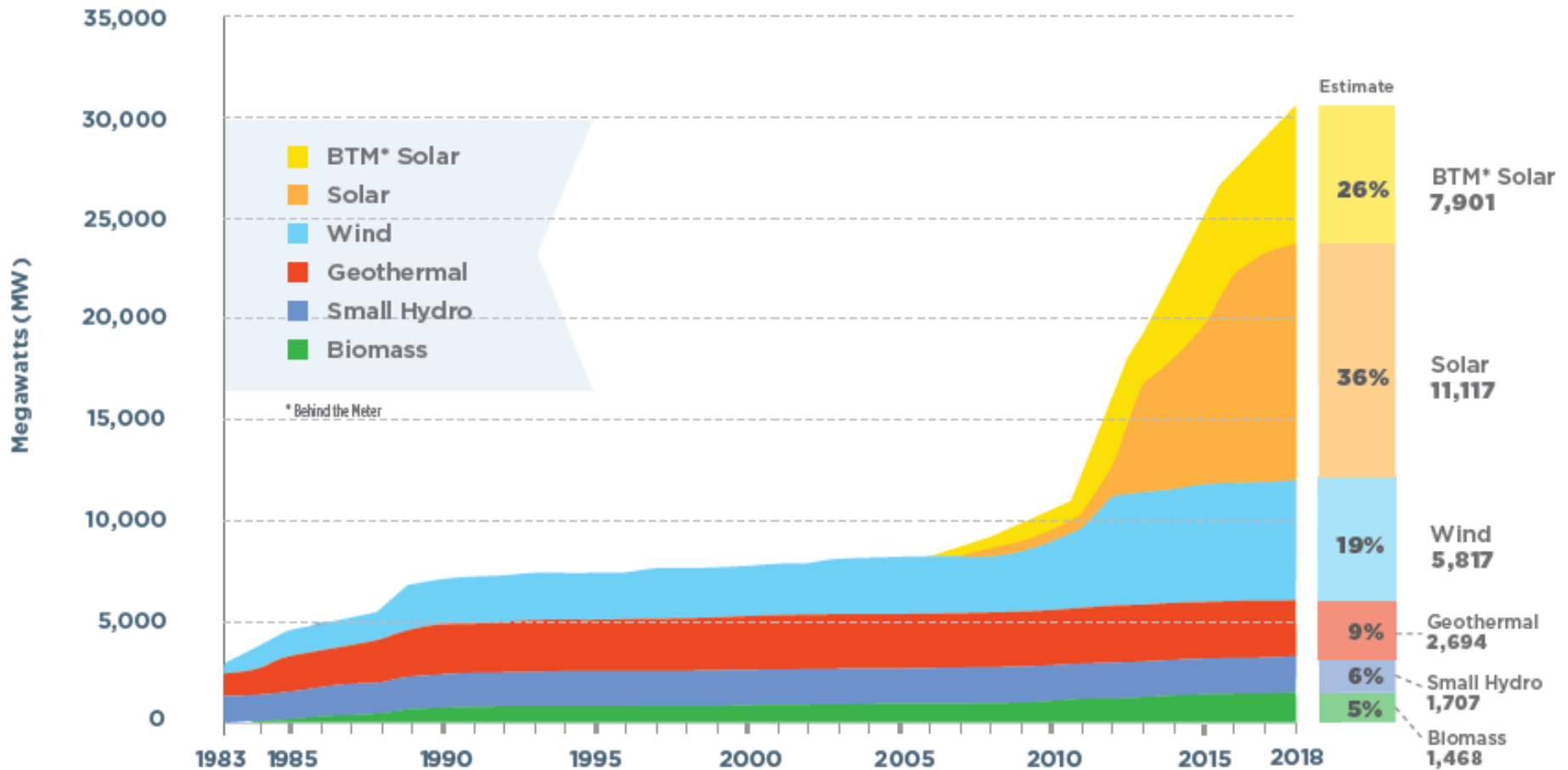


Source: Wood MacKenzie Power & Renewables

# Renewable Integration – CA Duck Curve



# California Renewables Growth



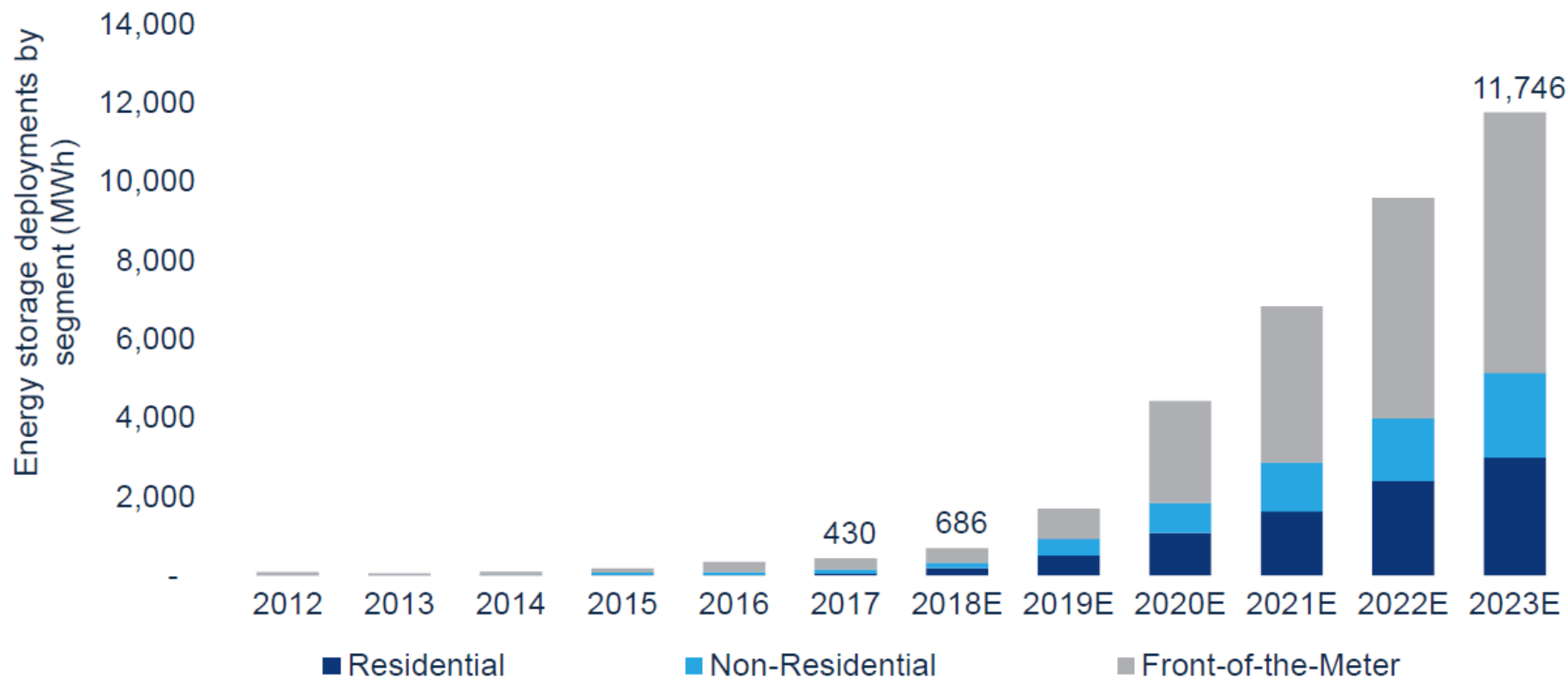
## Other reasons we need energy storage

- ▶ The grid is loosing inertia
  - Loss of baseload generation = less available spinning mass and reactive power
  - California examples
  - Need for dynamic reactive support devices is growing
  - Energy storage is a potential mitigation
- ▶ Renewable smoothing, shaping, and time shifting

# Market Outlook

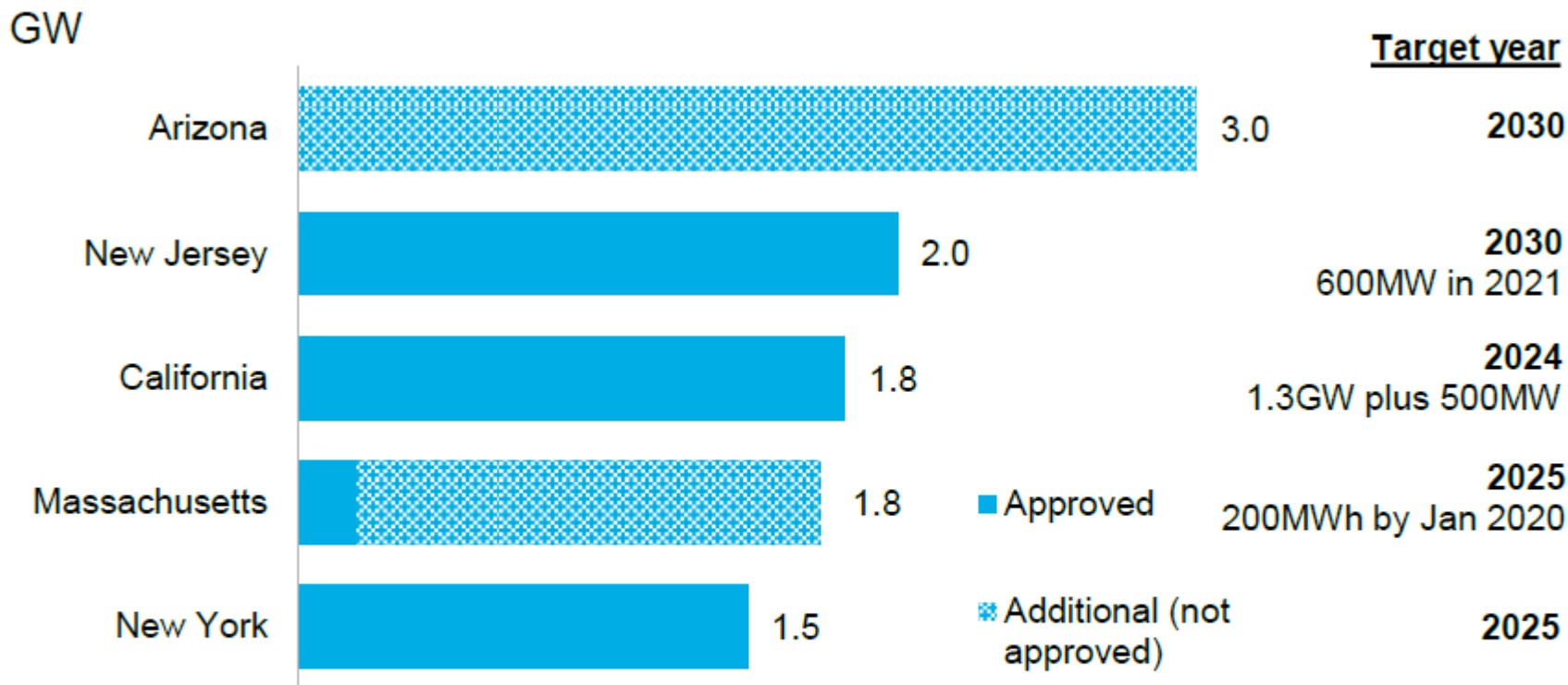
# Growth path to 12 GWh/year by 2023

U.S. energy storage annual deployment forecast, 2012-2023E (MWh)



Source: Wood MacKenzie Power & Renewables

# U.S. Energy Storage Targets

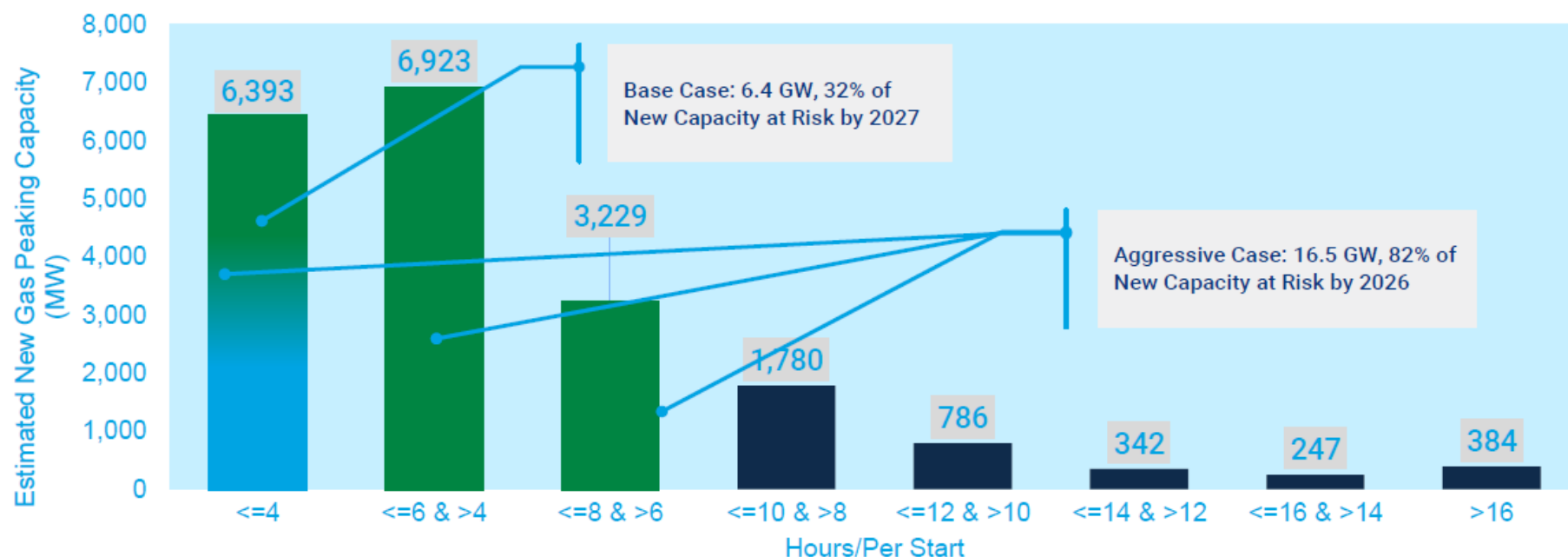


*Source: Bloomberg New Energy Finance. Note: Oregon 5MWh target on the two large utilities in the state was not included because it is too small to display.*

# Gas peakers at risk

## 6.4 GW or 32% of new peaker capacity at risk from 4-hour storage by 2027

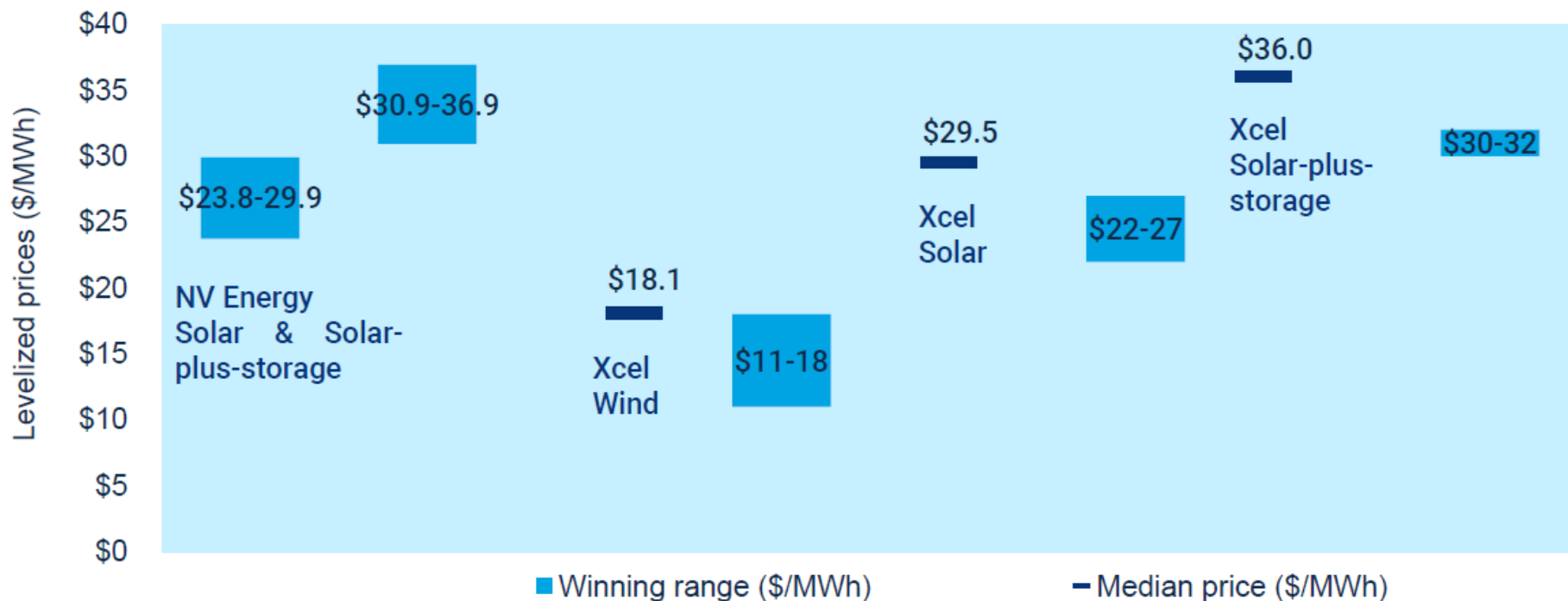
In aggressive case, 82% of new peaker capacity at risk from 8-hour storage by 2026



Source: Wood MacKenzie Power & Renewables

# Solar+Storage

## NV Energy and Xcel Colorado winning bids



Source: Wood Mackenzie Power & Renewables, NV Energy, Xcel Colorado

# FERC Order 841

Topic / RTO/ISO	CAISO*	ISO-NE	MISO*	NYISO	PJM*	SPP*
B. 1. Participation Model 2. Qualification Criteria 3. Existing Market Rules						
C. 1. Eligibility to Provide all Services 2. Ability to De-Rate Capacity						
D. 1. Participate as a Seller and Buyer 2. Prevent Conflicting Dispatch 3. Make Whole Payments						
E. Bidding Parameters						
F. SOC Management						
G. Minimum Size						
H. 1. Price for Charging Energy 2. Metering & Accounting						

Source: Energy Storage Association Website

# Some Recent Energy Storage Announcements

## ▶ APS Peaking Resource RFP

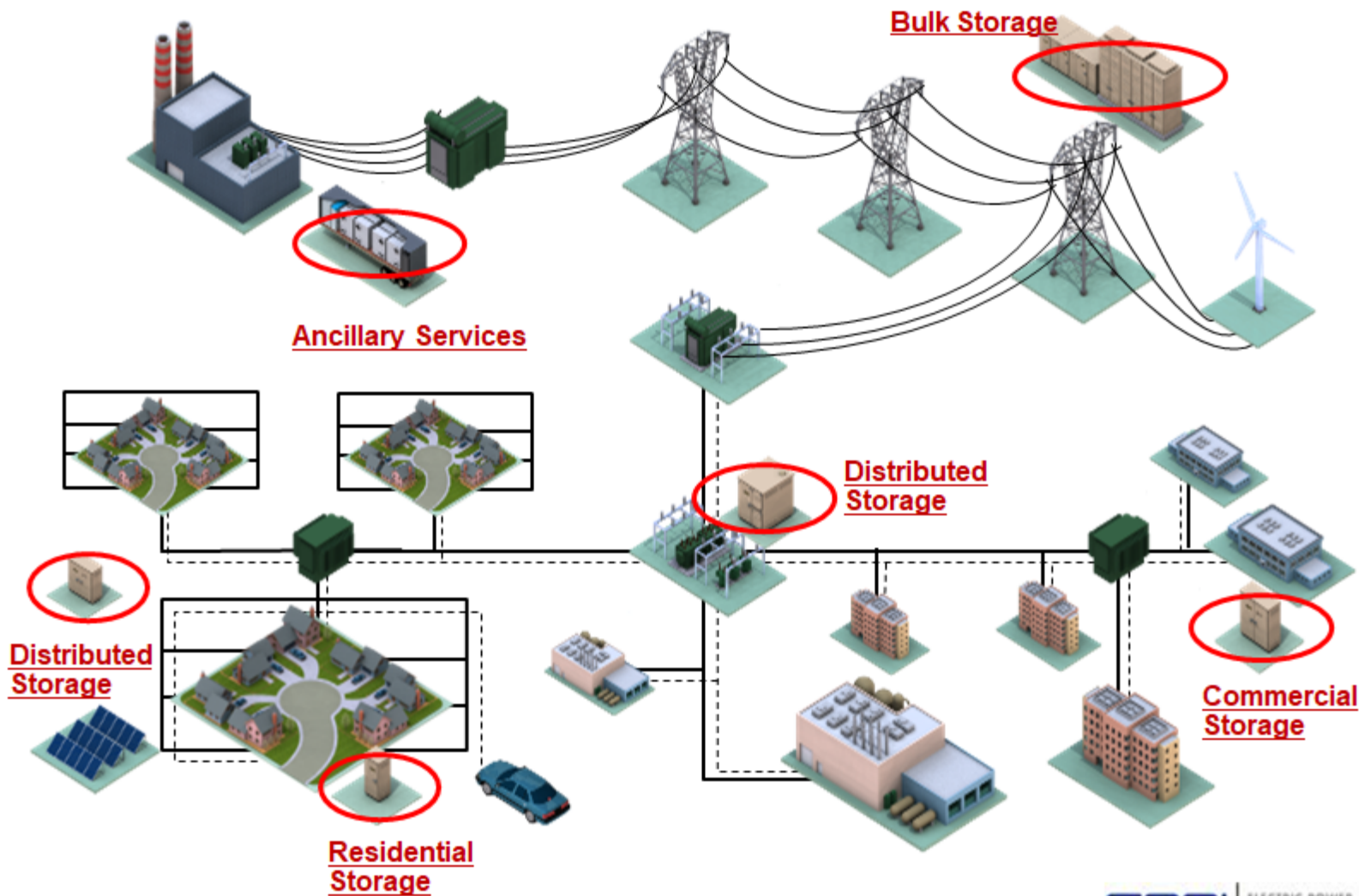
- Originally only planned for 100 MW of storage
- 850 MW of energy storage now planned by the mid-2020s

## ▶ PG&E Local Capacity Solicitation

- Selected total 567 MW / 2270 MWh energy storage
- Largest announced project at 300 MW / 1200 MWh
- Selected over existing gas-fired generation capacity

## ▶ SCE Aliso Canyon Fast Track Procurements

- Over 100 MW of energy storage projects completed in less than one year



# Thank You!

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