Energy Storage Overview
Peninsula Clean Energy Board Meeting

January 24, 2019

For:
Peninsula Clean Energy

Presented by:
ICF

ICF

PENINSULA CLEAN ENERGY

Energy Storage Topics

What is Energy Storage?

Services and Applications

What Does It Look Like?

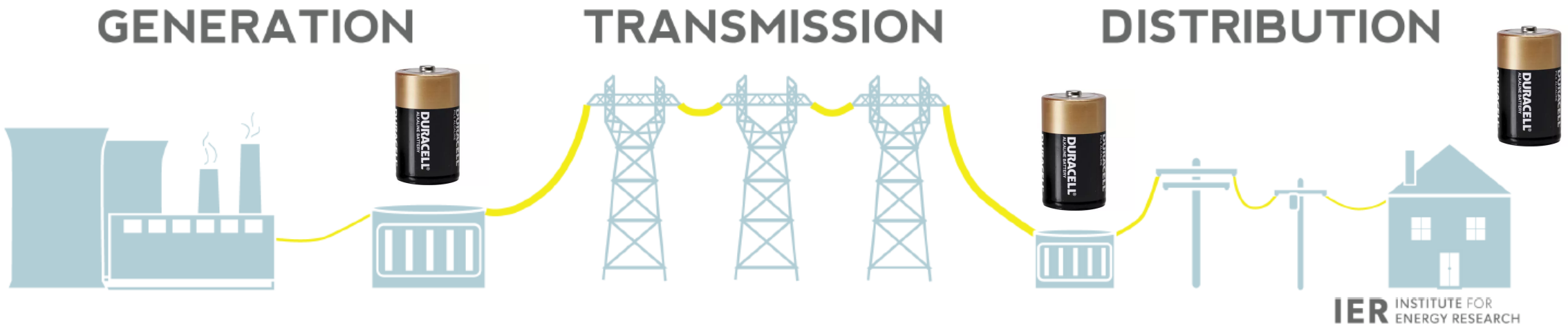
How Much Does They Cost?

PCE Goals and Energy Storage

What is Energy Storage?

What is Energy Storage?

- Technologies to store electricity when it is not needed so that it is ready to use when there is demand for electricity
- This is increasingly important with high % of renewable energy sources



How is Energy Storage Described?

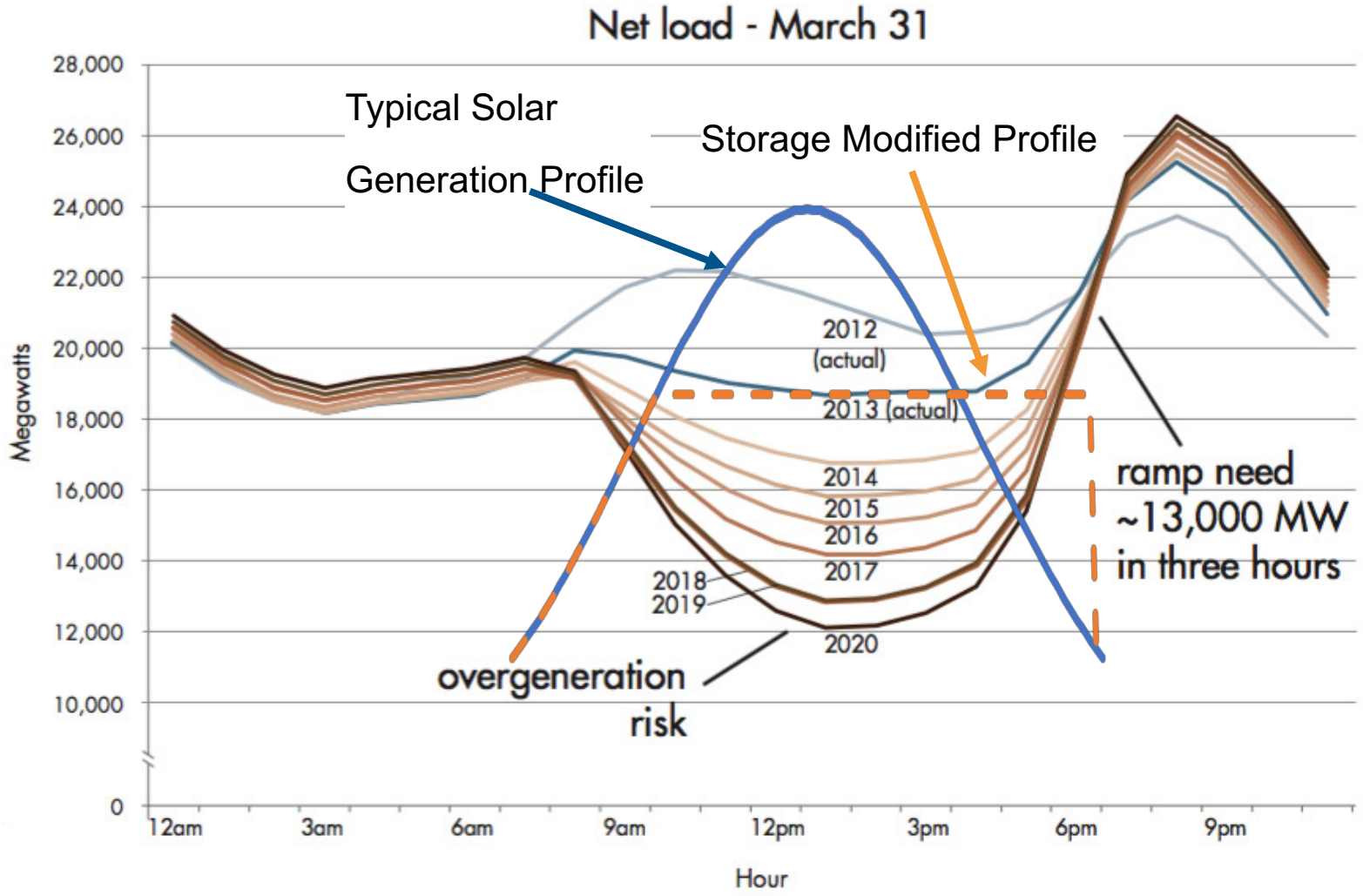
Storage is like a bucket of water…

Term	Energy Storage	Bucket of Water
Energy Capacity	Amount of energy stored (kWh or MWh)	How much water the bucket can hold
Power Capacity	Rate at which energy is charged or discharged (kW or MW)	How fast the bucket can filled/emptied
Duration	Ratio of energy and power capacity (hours)	How long it takes to fill/empty the bucket
Efficiency	The amount of energy lost during charging/discharging (%)	Water splashes when filling/emptying
Cycle Life	The number of charges/discharges before energy capacity falls below a certain level	Holes in the bucket form over time

What Types of Storage Exist?

- Scale: utility, commercial and industrial, residential
- Type of service
  - front of the meter (FTM): grid services, ancillary services
  - behind the meter (BTM): customer services
- Stand-alone or coupled with generator
- Stationary or mobile (trailer, electric vehicles)

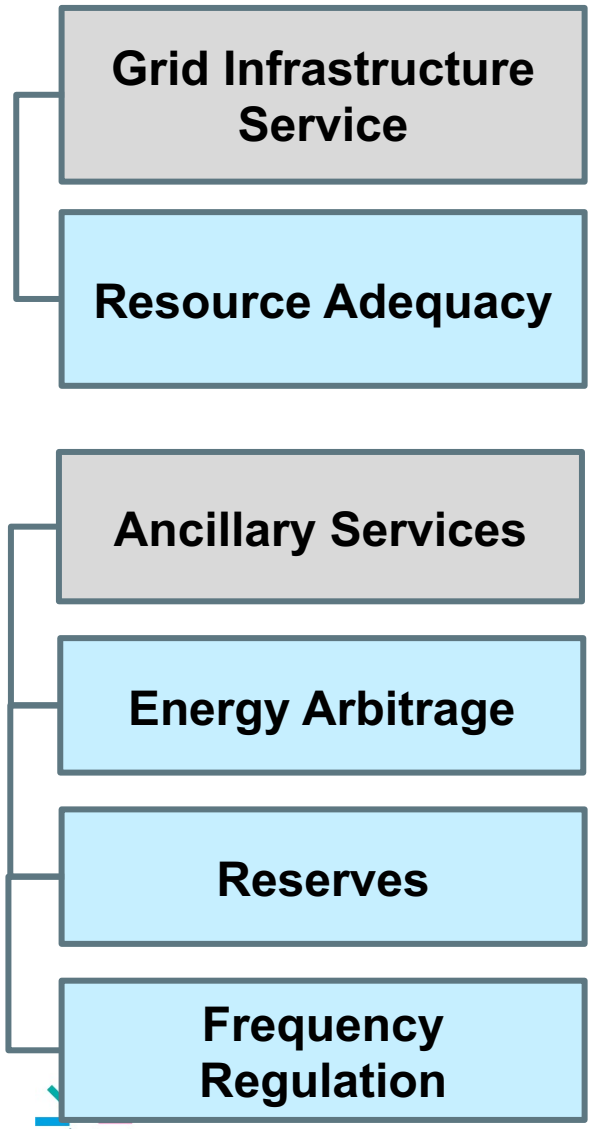
Duck Curve - CAISO



Source: https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

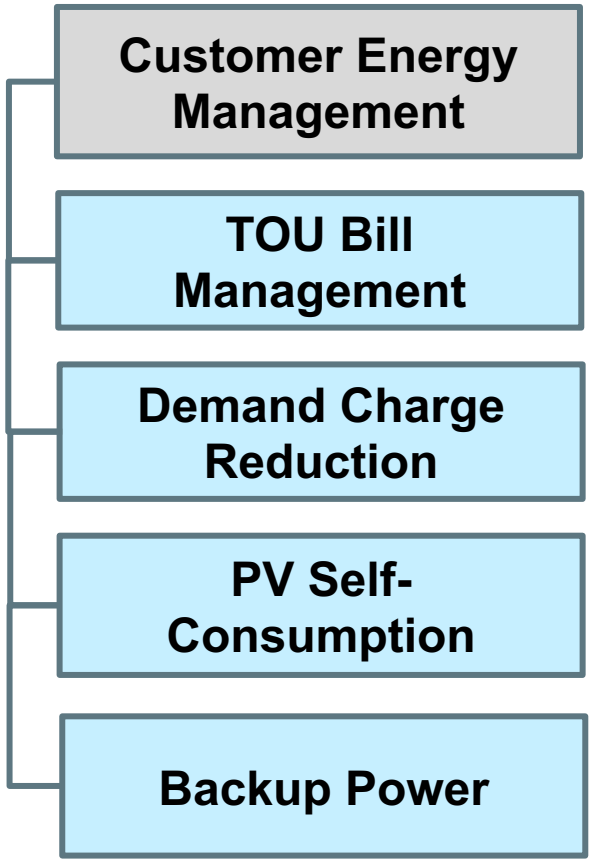
Services and Applications

FTM Services Relevant to PCE



Application	Description
Resource Adequacy	Supply capacity to meet peak electricity demands
Energy Arbitrage	Store excess energy and dispatch when valuable
Reserves	Standby capacity for unplanned capacity losses occur
Frequency Regulation	Regulate frequency of grid to maintain power quality

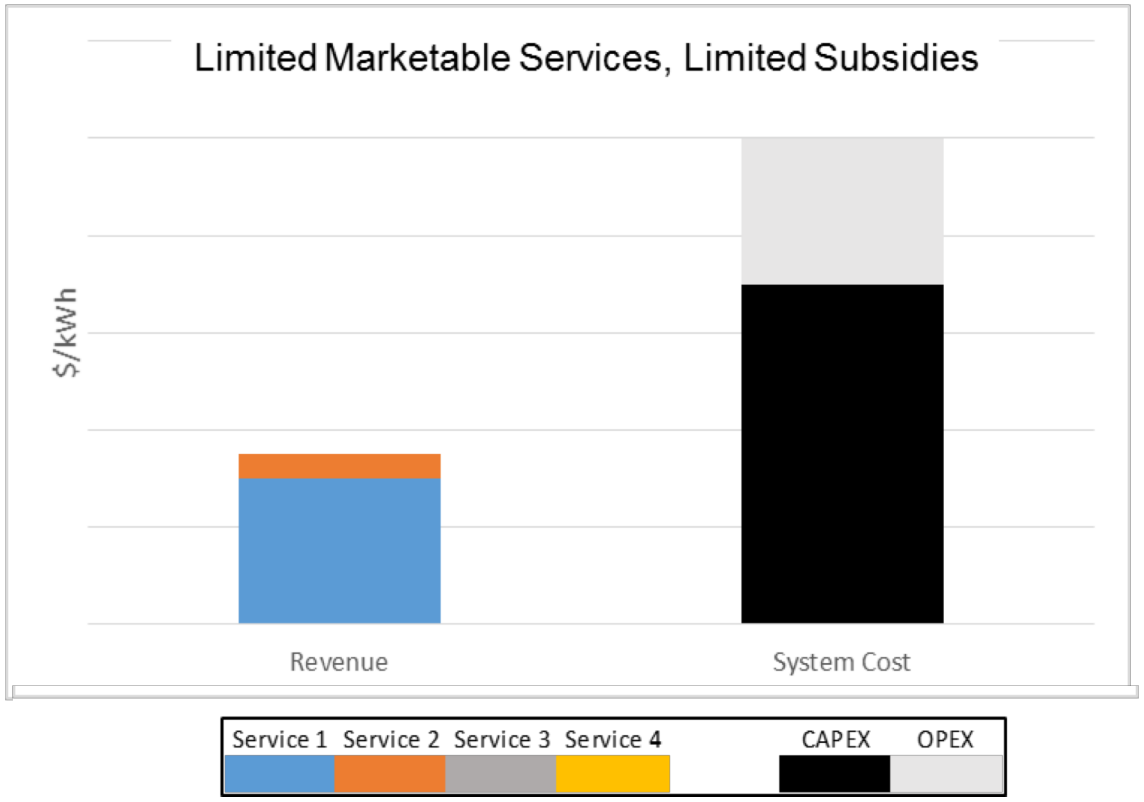
BTM Services Relevant to PCE

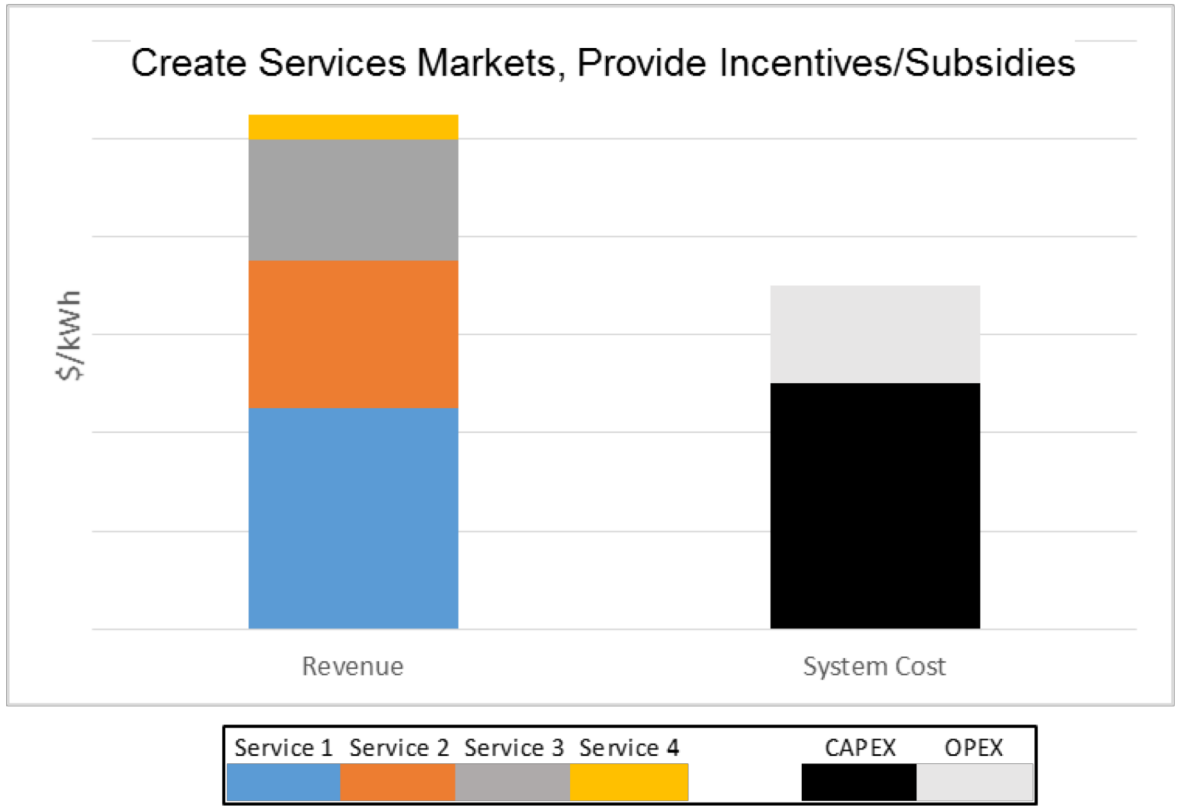


Application	Description
TOU Bill Management	Reduce energy purchases during peak consumption hours
Demand Charge Reduction	Reduce consumption when demand charges high
PV Self-Consumption	Store PV generation for use later
Backup Power	Provides energy during power outages

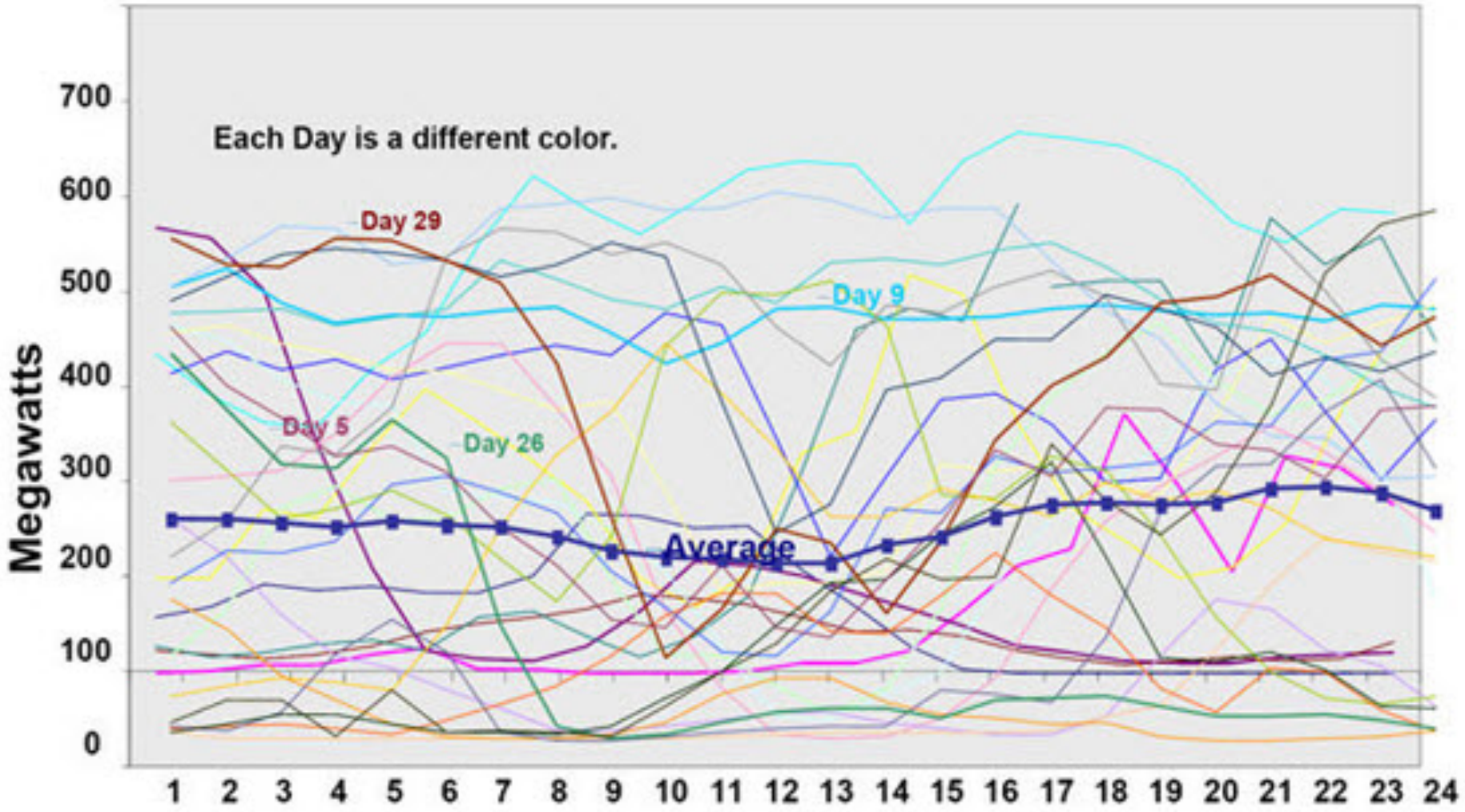
Stacking Services

Storage owner can combine (stack) various applications to increase revenue opportunity

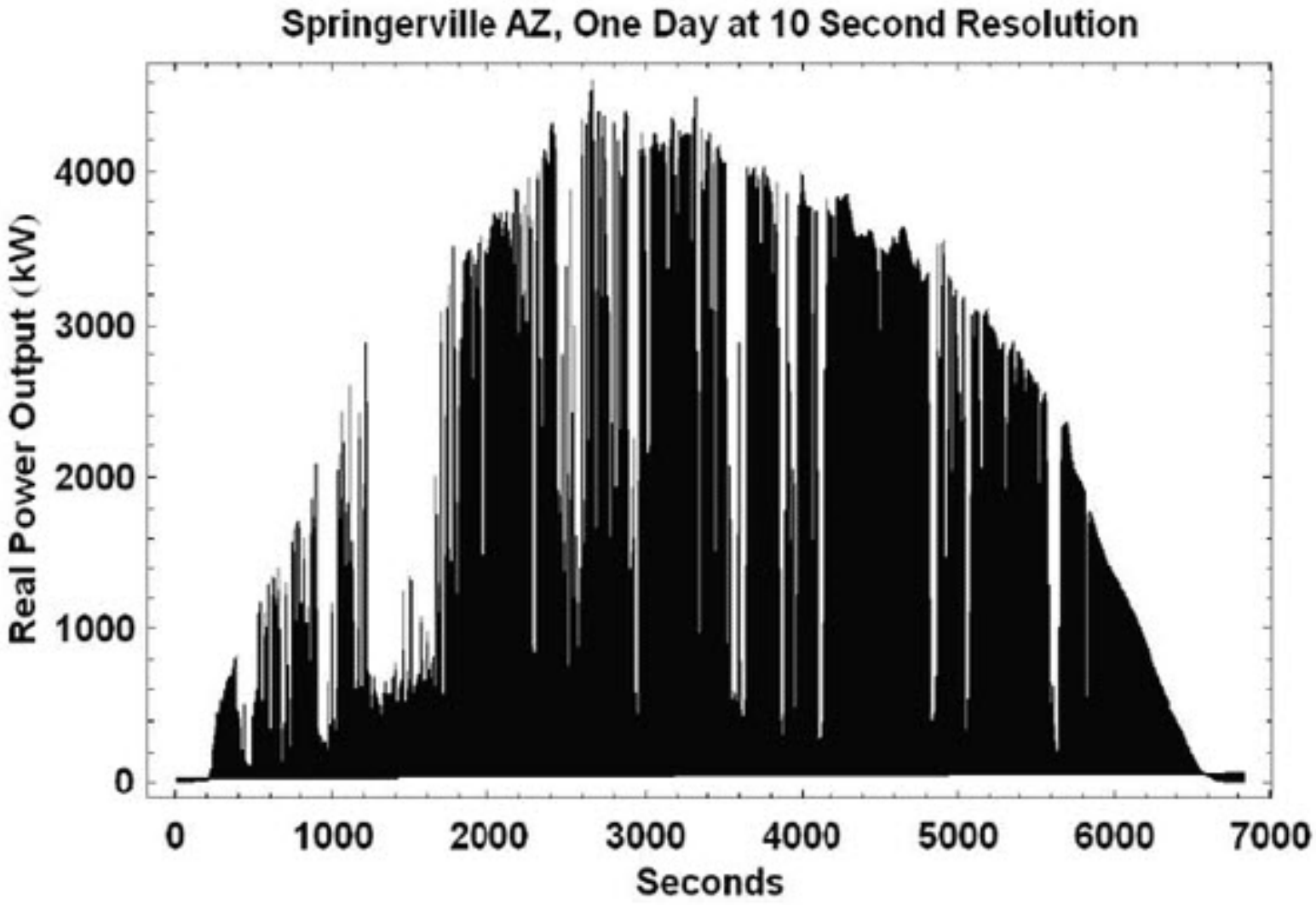




Renewable Specific Applications - Wind

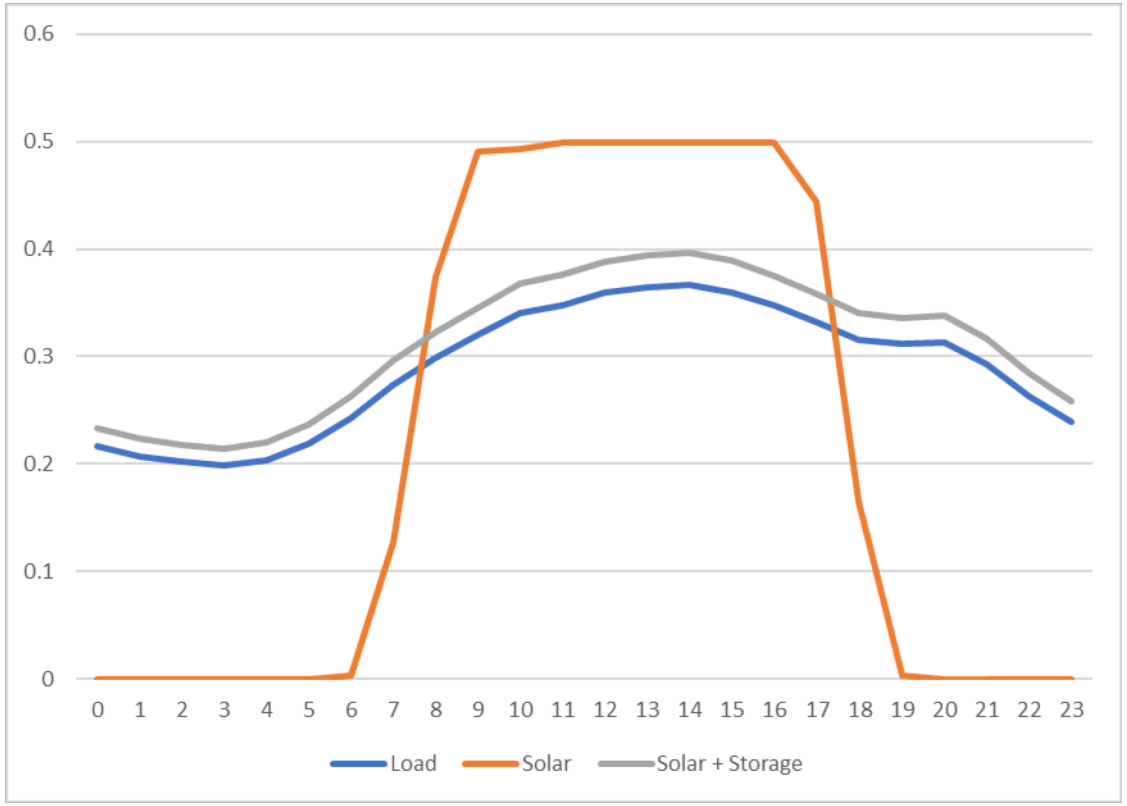


Renewable Specific Applications - Solar

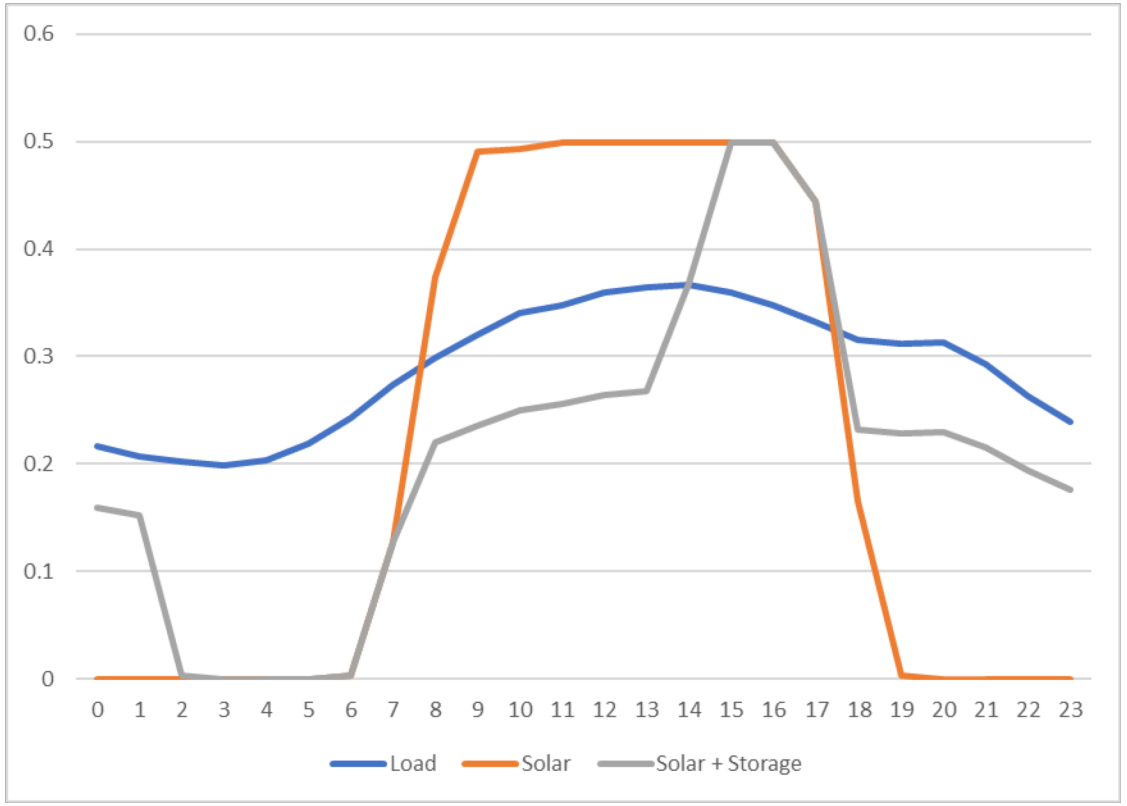


Renewable Load Matching

Storage can shape the output of renewable energy to match load



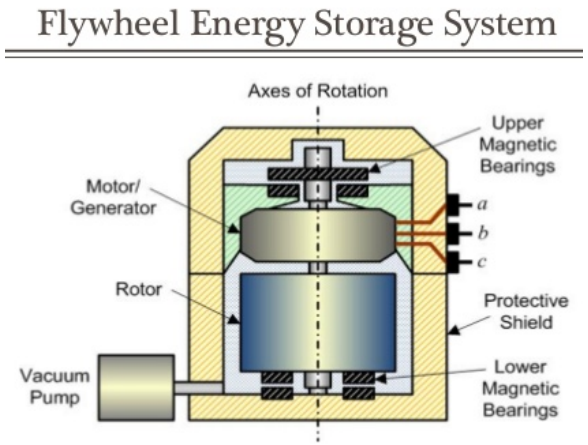
Very Large ESS

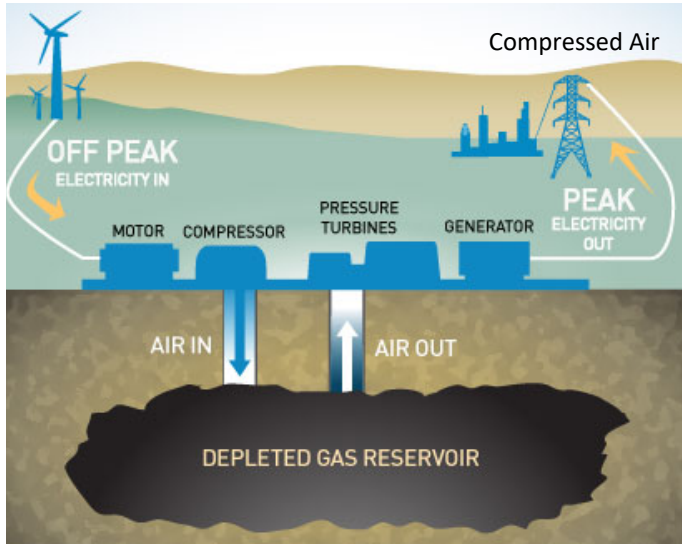


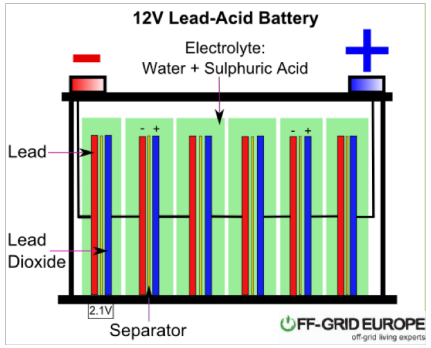
Typical ESS

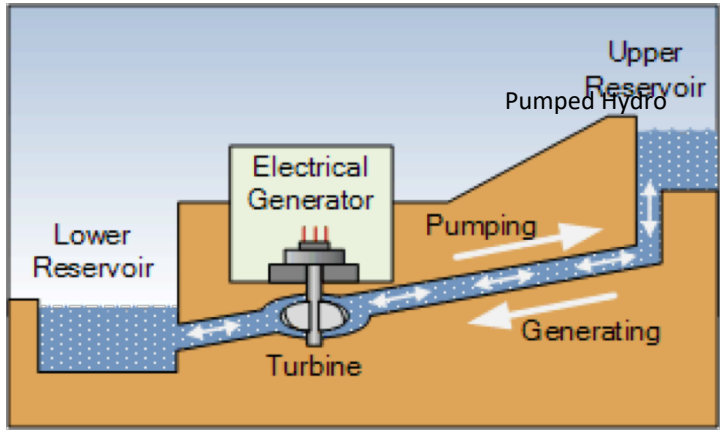
What Does It Look Like?

Many Types of Energy Storage

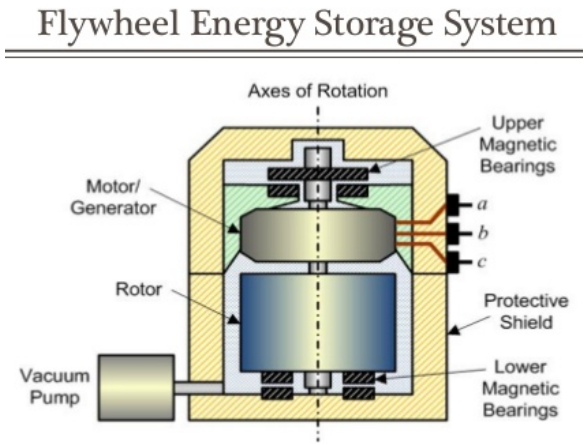


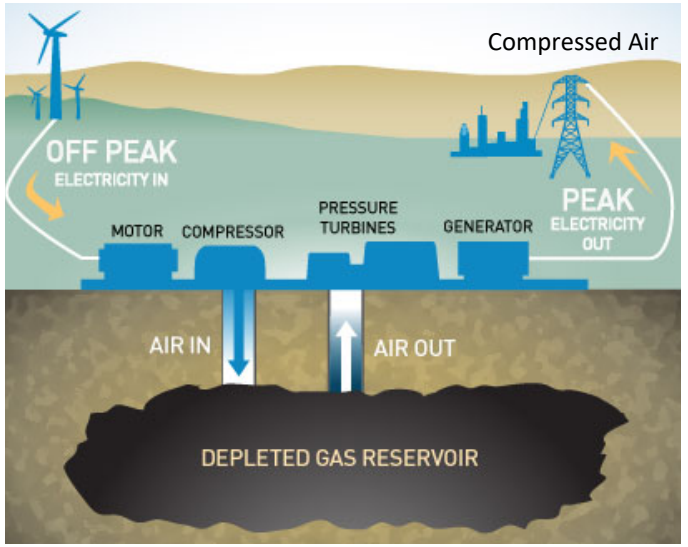


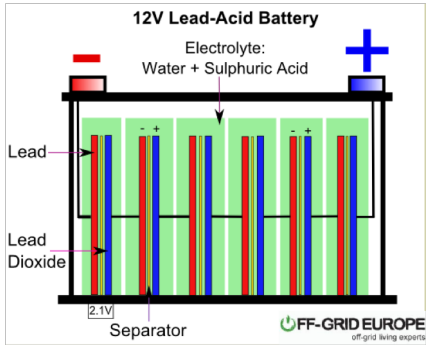


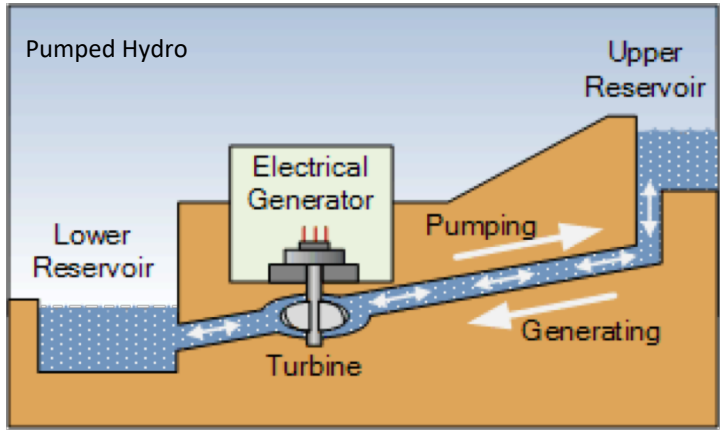


What Technology is Relevant?







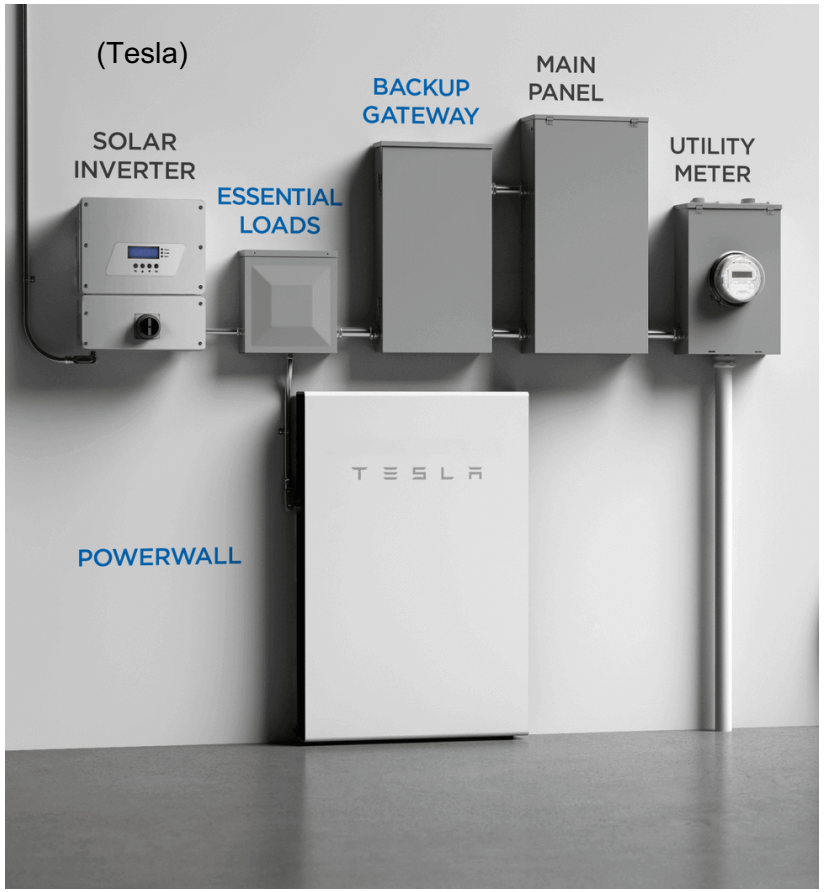


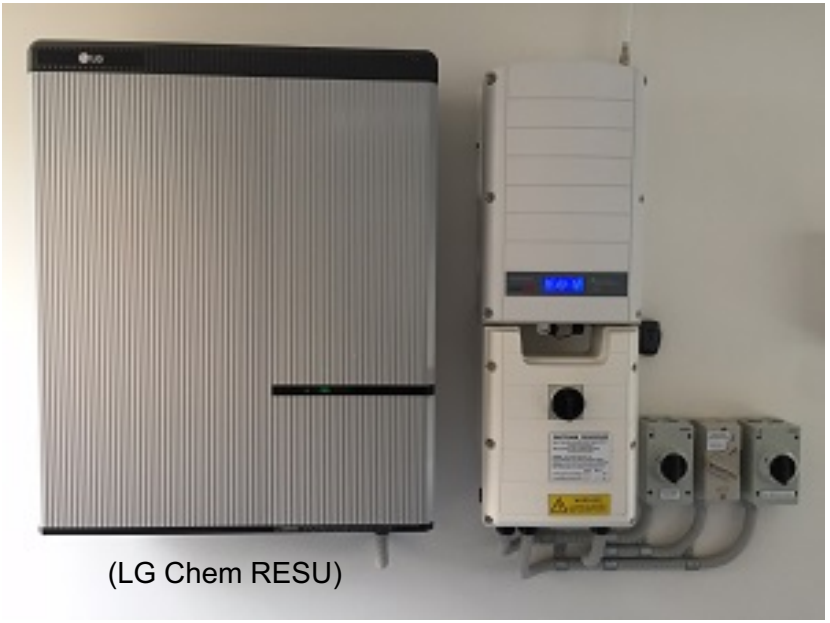
Why?

- Battery storage is:
  - Compact
  - Limited infrastructure requirements
  - Scalable
- Lithium-ion is the clear front runner
  - Cost
  - Flexible
  - Mature
- Others have promise but: expensive, limited services, lack field history
- Performance considerations (Li-ion)
  - Efficiency → ~90%
  - Lifetime → ~ 10 years

Residential Storage

- Typically 3-10 kW, 5-20 kWh, 2 or 4 duration
- Lithium ion batteries
- Cost: $1025-1800/kWh installed
- Typical Applications
  - TOU management
  - PV self consumption
  - Backup




(LG Chem RESU)

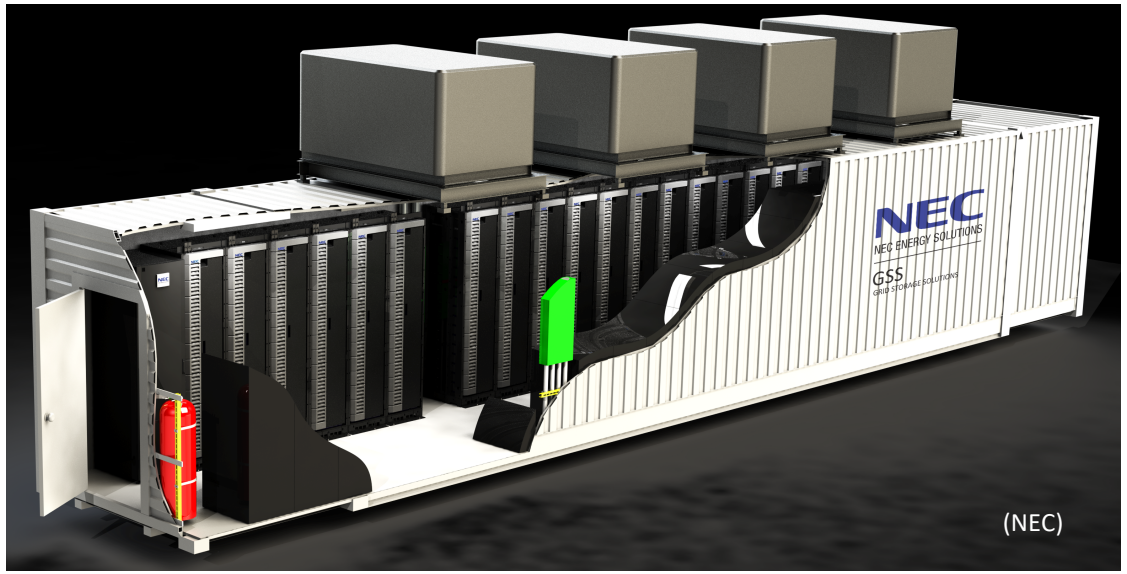
Commercial & Industrial Storage

- Typically 50-500 kW, 50-2000 kWh, 2-4 hour duration
- Lithium ion batteries
- Cost: $725-1375/kWh installed
- Typical Applications
  - TOU management
  - PV self consumption
  - Demand Charge Management
  - Power Quality/Backup

(Lockheed Martin)

(Tesla)

Utility Scale Storage

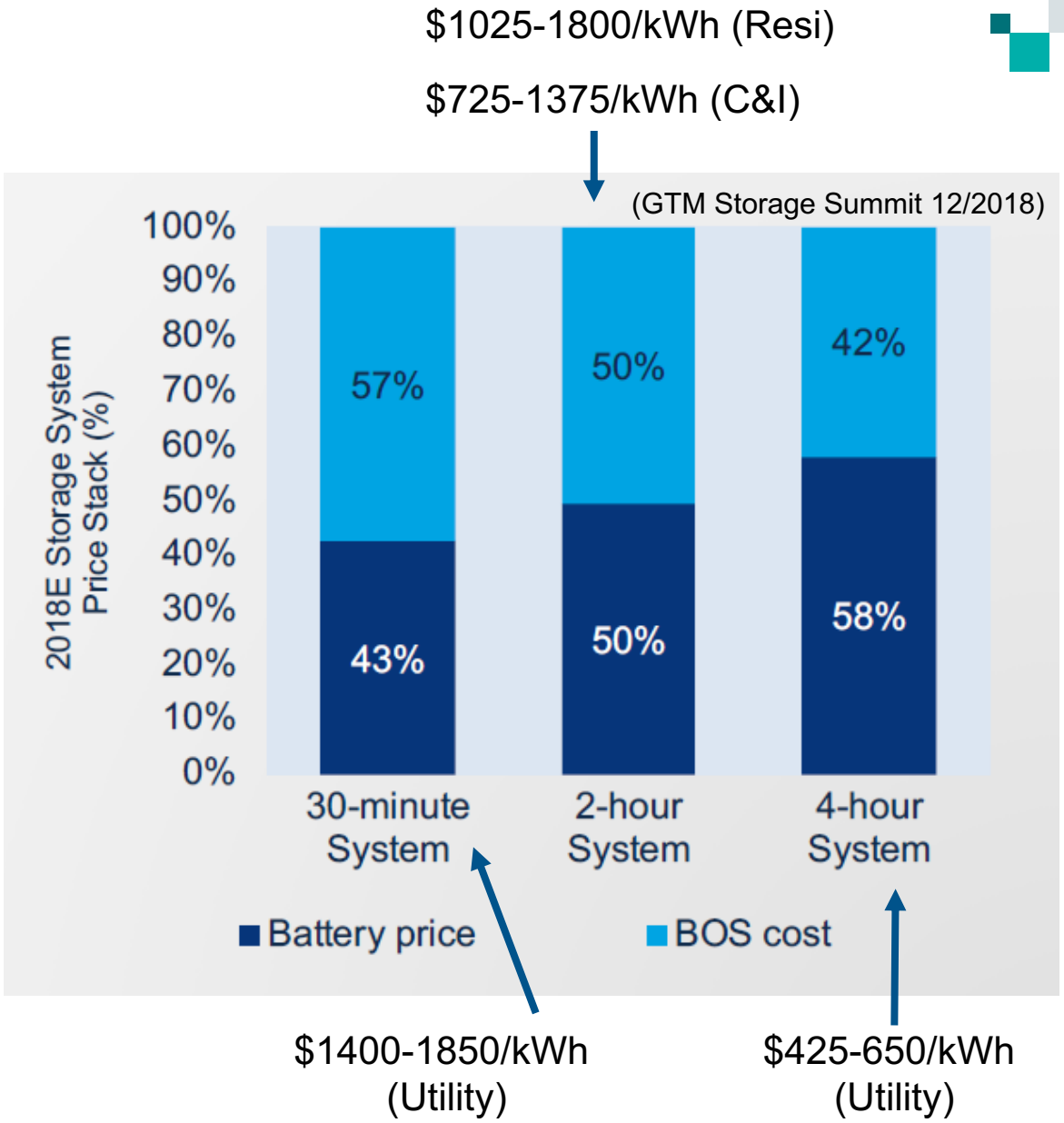


- Typically 5 MW, 20 MWh, 4 hour duration
- Lithium ion batteries
- Cost: $425-650/kWh installed
- Typical Applications
  - Grid/Ancillary Services
  - Load Matching
  - Energy Arbitrage

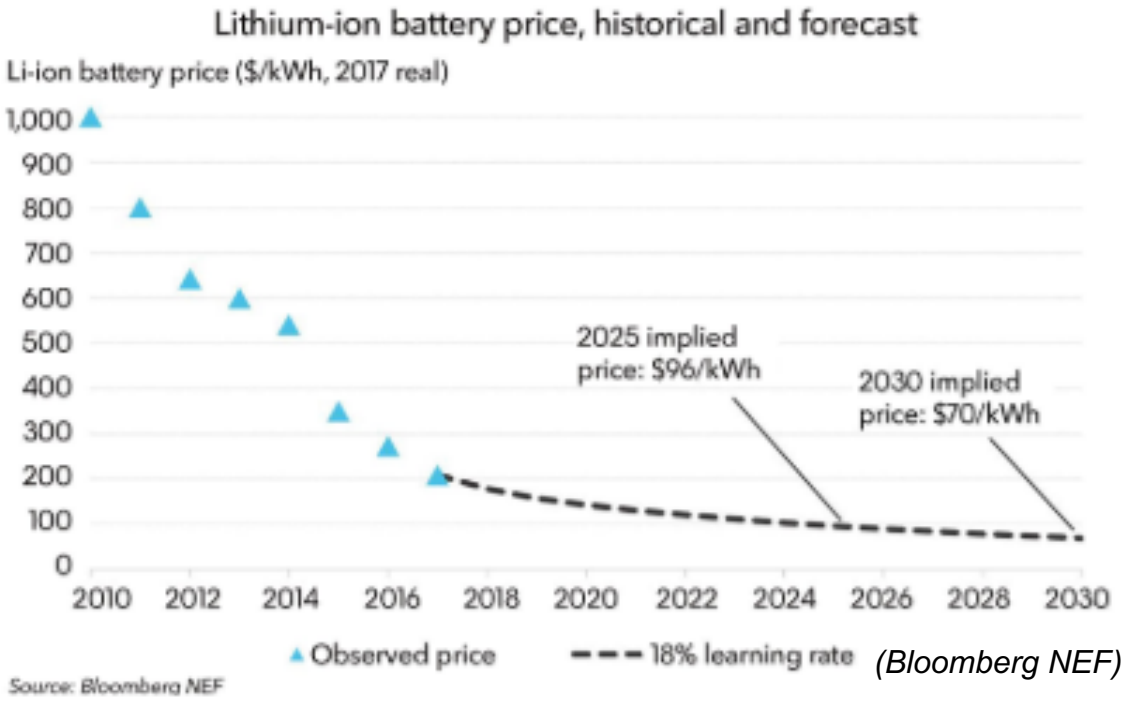
How Much Do They Cost?

Storage System Costs

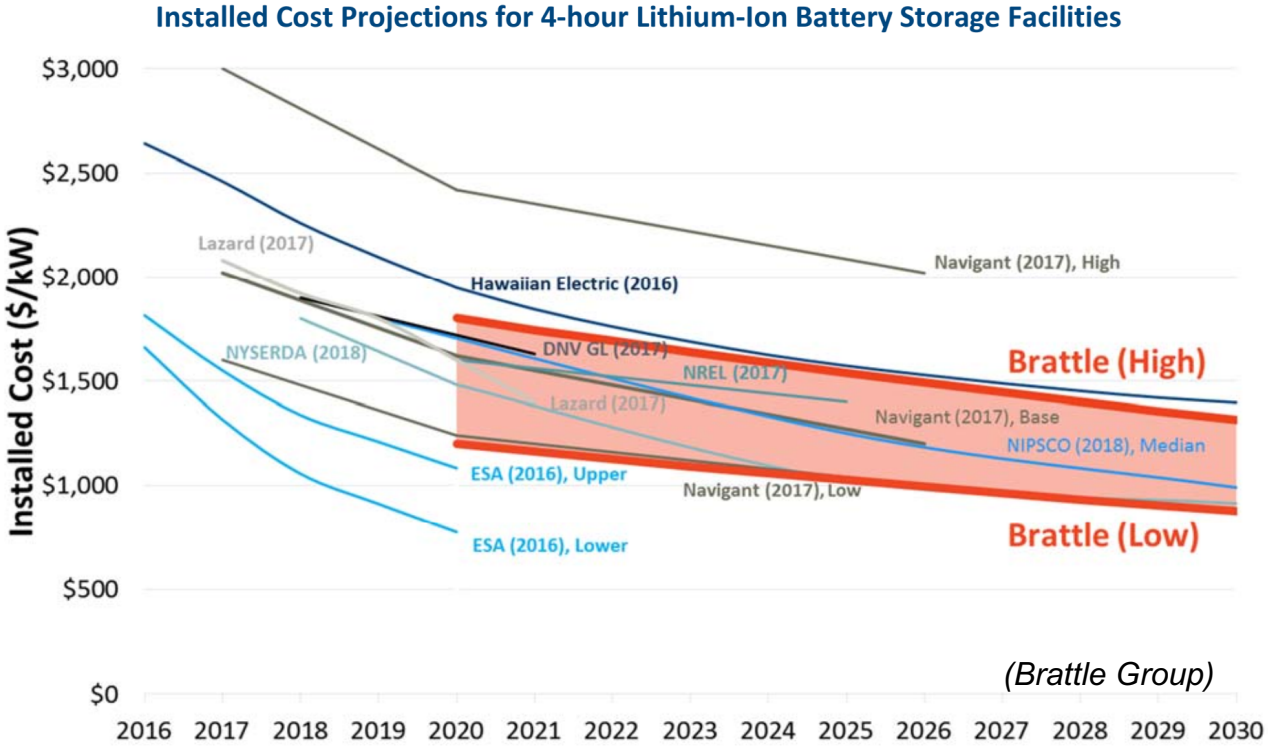
- Battery cost main driver for all costs
- Capital Costs
  - Installation
  - Batteries
  - Balance of system (everything else)
- Operating Costs:
  - Maintenance
  - Energy capacity augmentation



Costs – Past, Present, and Future



(Bloomberg NEF)



(Brattle Group)

- 80% price drop since 2010
- ~$70/kWh by 2030, ~$40/kWh by 2040

- Systems prices follow battery prices

PCE Goals and Energy Storage

PCE Policy, Goals & Objectives

Reduce Greenhouse Gases (GHG)

- Steady progress in reduction of PCE portfolio GHG
- 90% GHG free in 2019 with target of 100% GHG-free in 2021

PCE Supply Portfolio

- Evolve supply portfolio (energy) to ~100% renewable by/before 2025, subject to resource availability and market cost-effectiveness
- Manage supply portfolio to match ~100% renewable supply with customer demand on an hourly basis

How can energy storage support these goals?

Opportunities for Storage and PCE

- **Energy**
  - Shaping RE output to match load & meet ~100% RE objectives
  - Economically dispatch energy into CAISO day ahead or real time markets

- **Capacity (Resource Adequacy)**
  - System, Local, Flexible
  - Storage can provide RA but must participate in CAISO markets

- **Ancillary Services**
  - Regulation Energy Management
    - Frequency Regulation and Reserves

New rules at CAISO are being developed and market for products/services is evolving

Thank You!