Energy Storage

Opportunities and Technical Priorities

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NASEO Regional Meeting
5/14/19

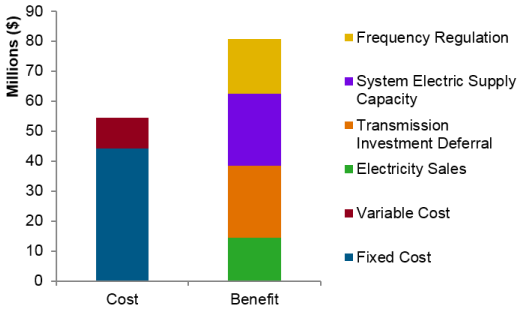
EPRI Energy Storage Program Mission

Advance integration and use of safe, reliable, cost-effective and environmentally responsible energy storage

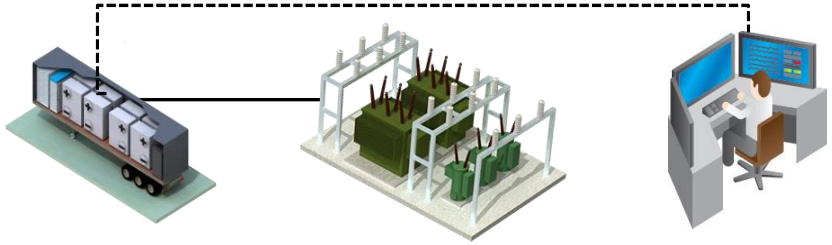
- Technology evaluation and testing
- Techno-economic analysis methods and tools
- Grid integration and control
- Safety and environmental impacts
- Industry collaboration and common approach development

EPRI Guiding Vision

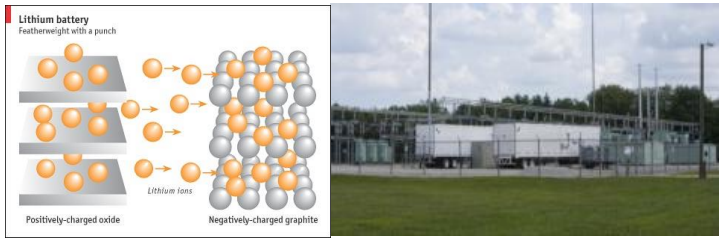
Storage Valuation



Storage Integration



Evaluation and Demonstration



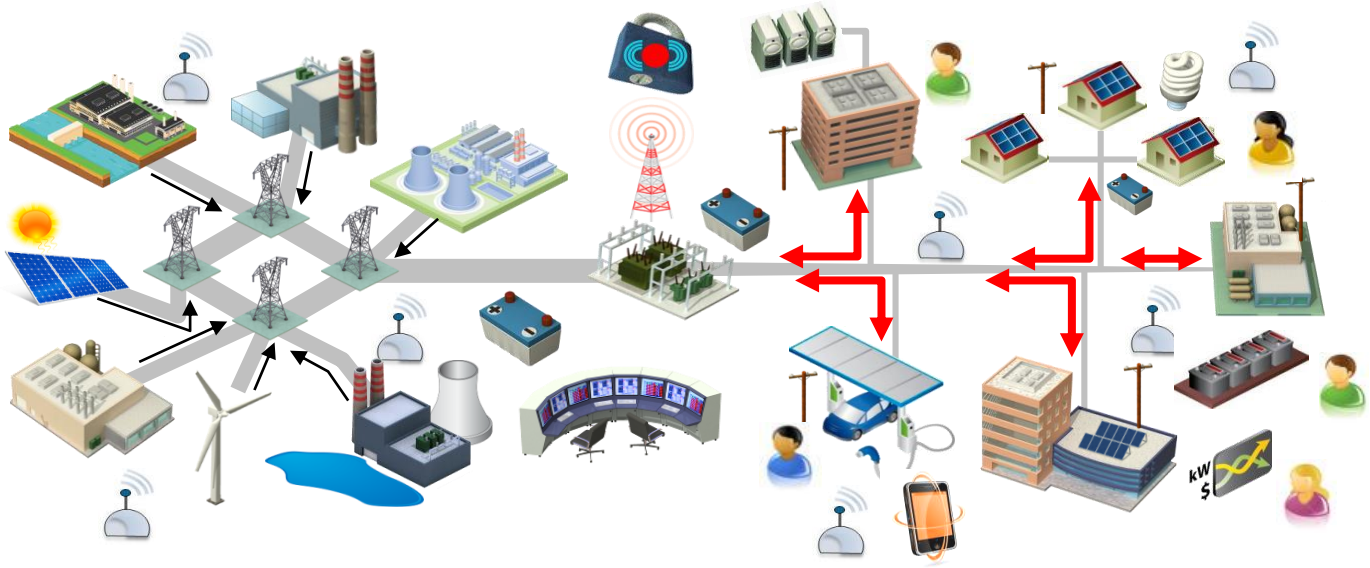
Agenda

- Energy storage technology intro
- Storage applications and value
- Current EPRI research focus areas
- Available resources

Energy Storage Technology Intro

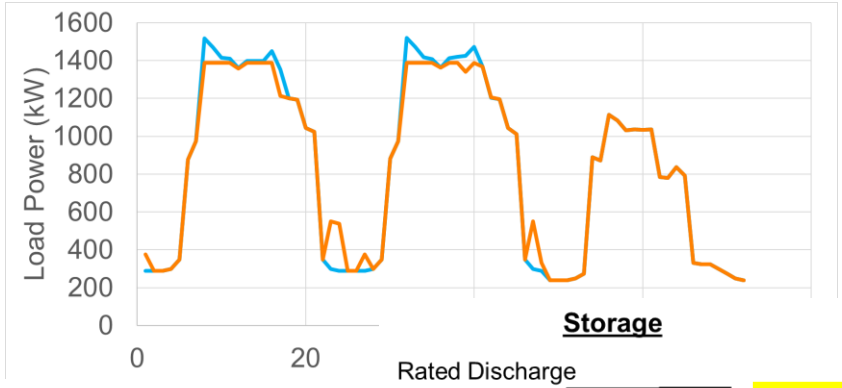
Energy Storage Complements a Changing Grid Ecosystem

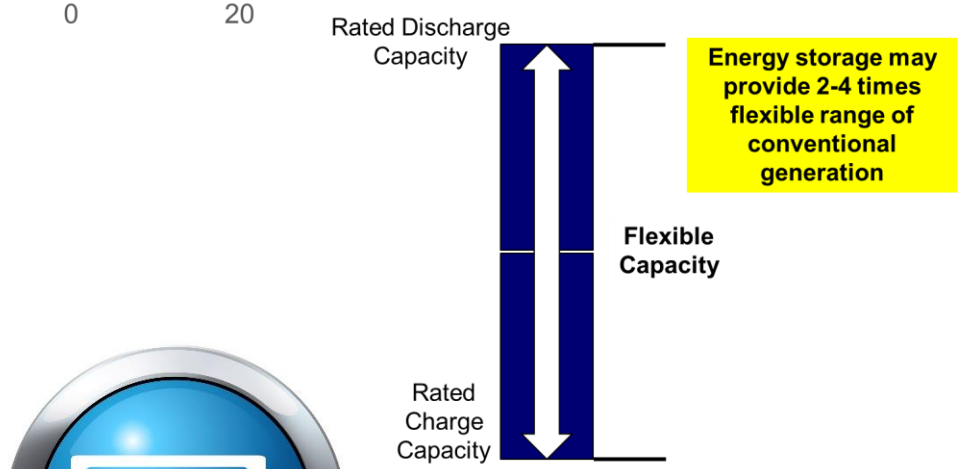
- Renewable energy
- Distributed energy and customer choice
- Electrification
- Resiliency
- Grid modernization and digitization

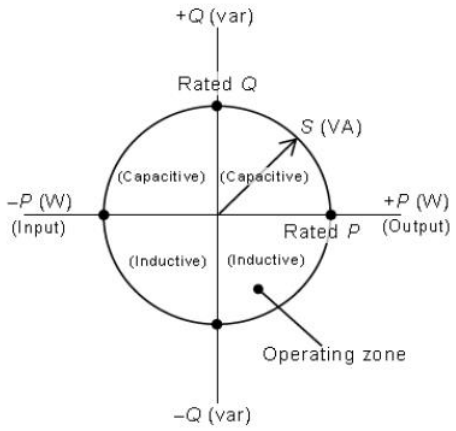


Capabilities of Storage

- **Capacity Resource**: Firm power
- **Flexibility Resource**: Fast response and ramping
- **Backup Resource:** Energy reserve
- **Power Quality Resource:** 4-quadrant watts and VARs







Diverse Energy Storage Technologies

Electrochemical ("Batteries")

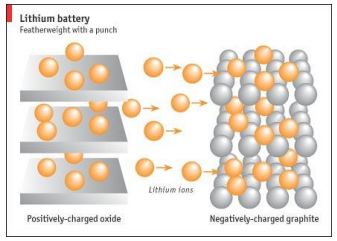
Lithium ion

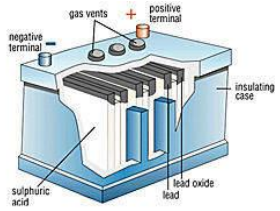
Lead acid

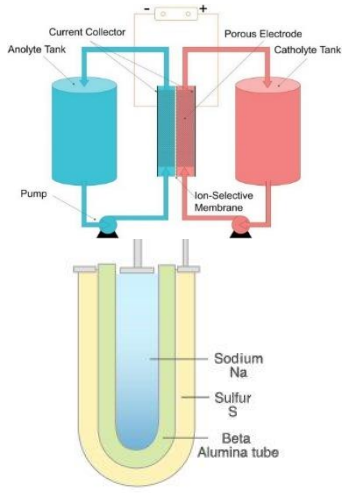
Sodium-beta

Flow batteries

…and more

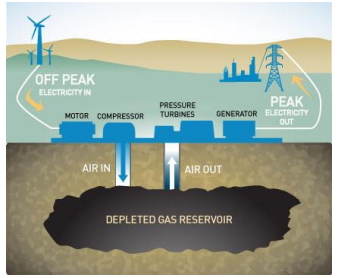




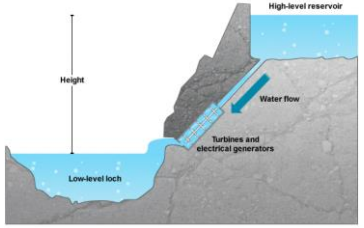


Electromechanical

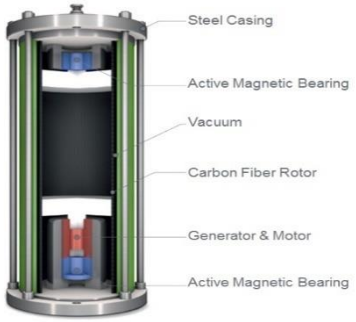
Compressed Air (CAES)



Pumped Hydro



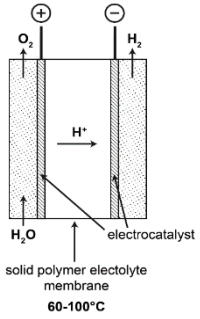
Flywheel



Source: Stornetic

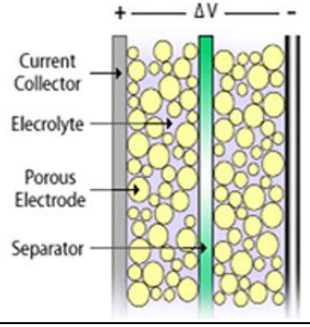
Chemical

Hydrogen, Synthetic Fuels

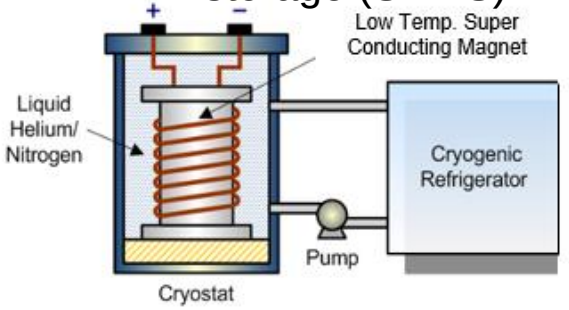


Electrical

Capacitors

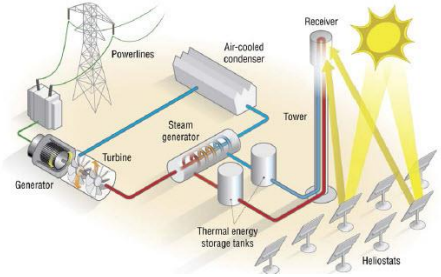


Superconducting magnetic storage (SMES)

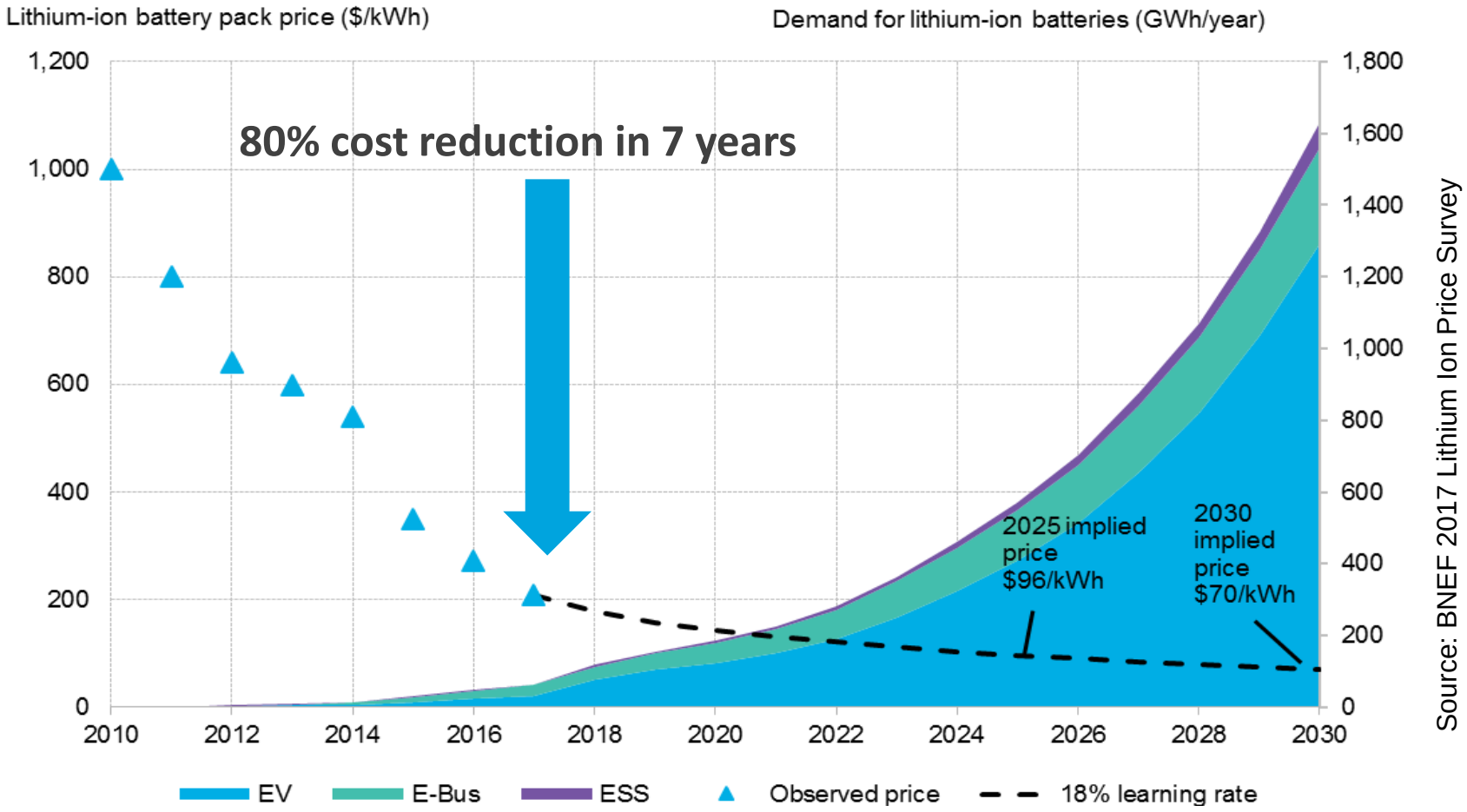


Thermal

Molten salt solar, thermal storage

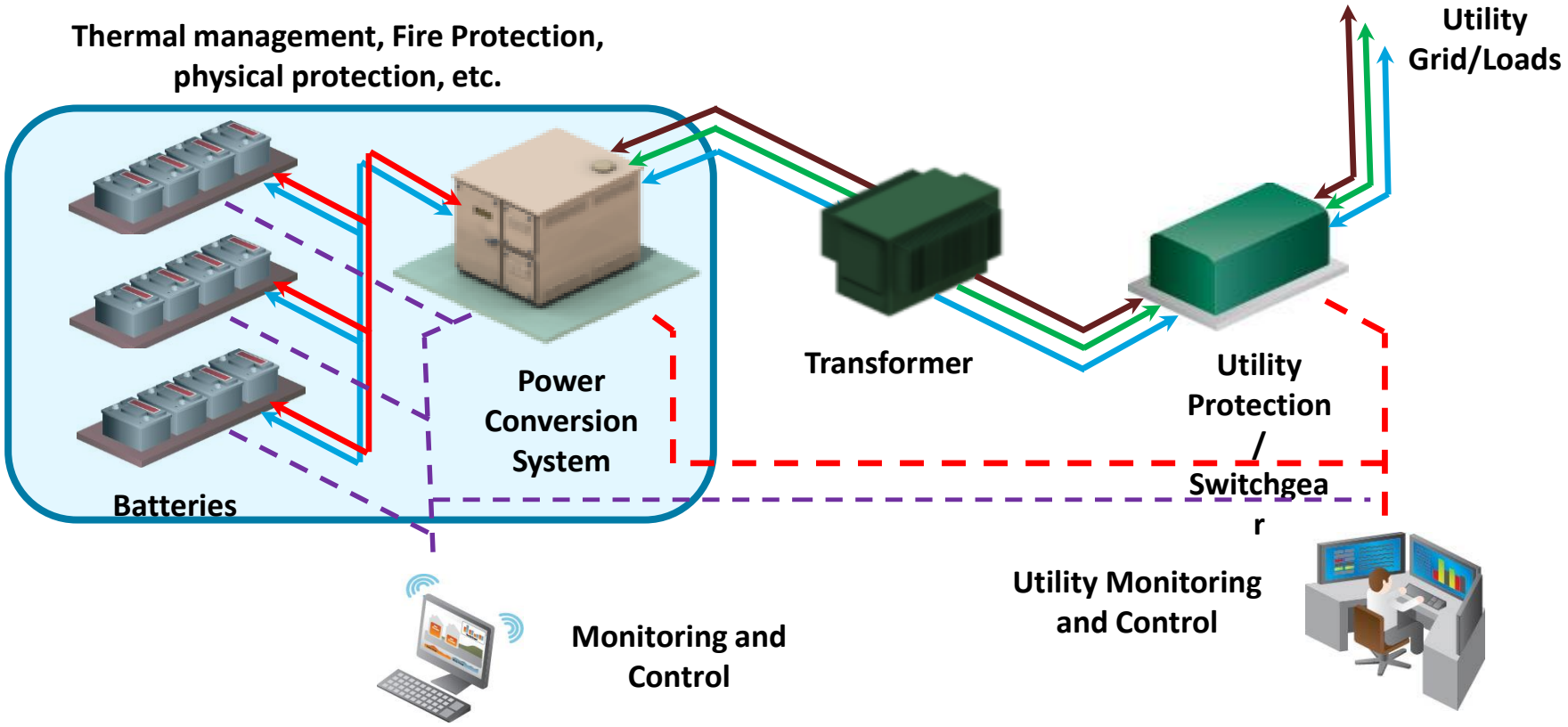


Lithium ion batteries are improving rapidly



Massive R&D investment and manufacturing scale-up for EV are driving performance and cost improvements

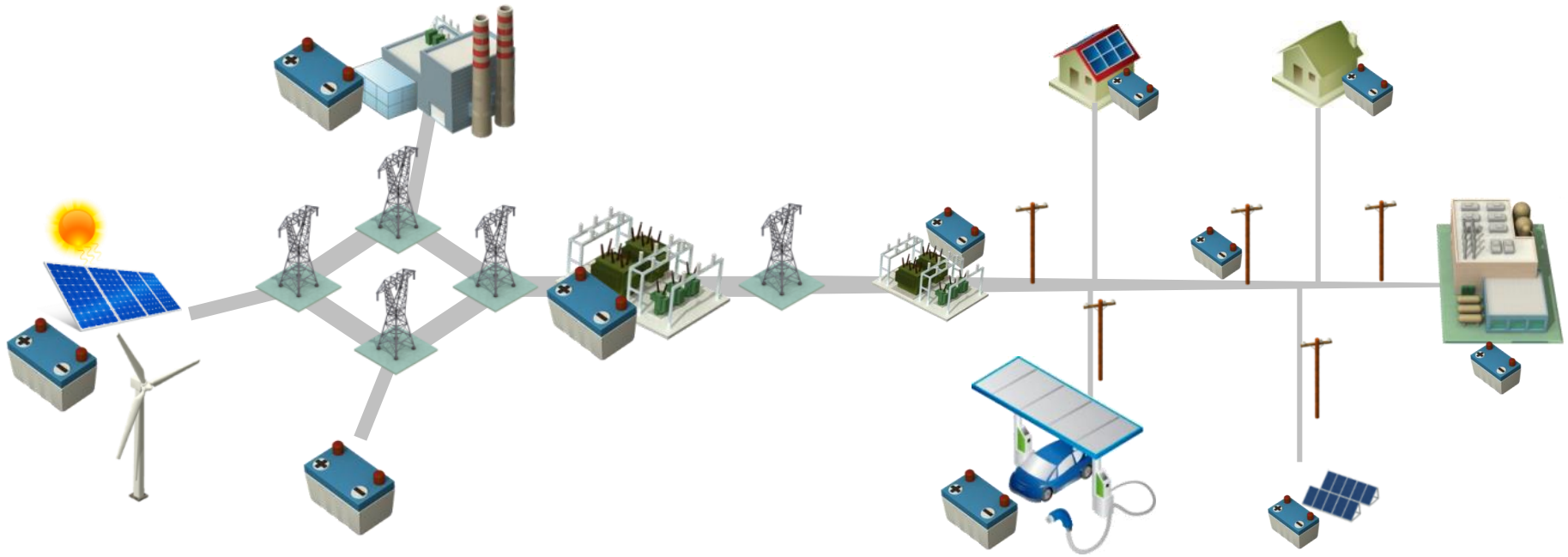
Other components and product / grid integration is required



Energy storage products rapidly emerging, but safe, effective usage has learning curve

Storage Applications and Value

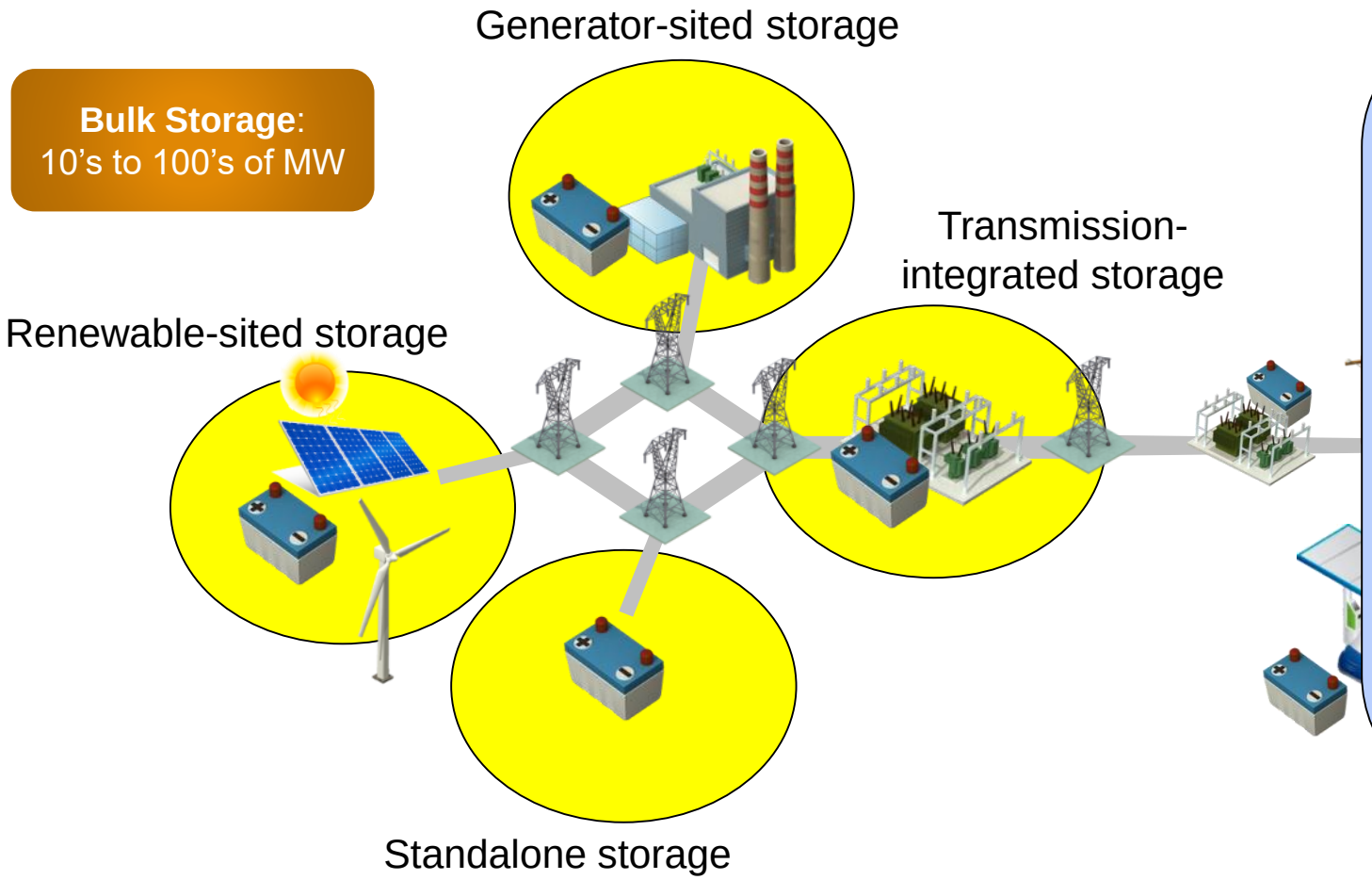
Energy Storage Applications



Modularity of battery storage and diversity of needs opens possibility for many applications

Energy Storage Applications – Generation & Transmission

Bulk Storage:
10's to 100's of MW



Transmission-Connected Storage

May provide:

- Generation capacity (resource adequacy)
- Black start
- Virtual transmission capacity
- Energy time-shifting
- Ancillary services

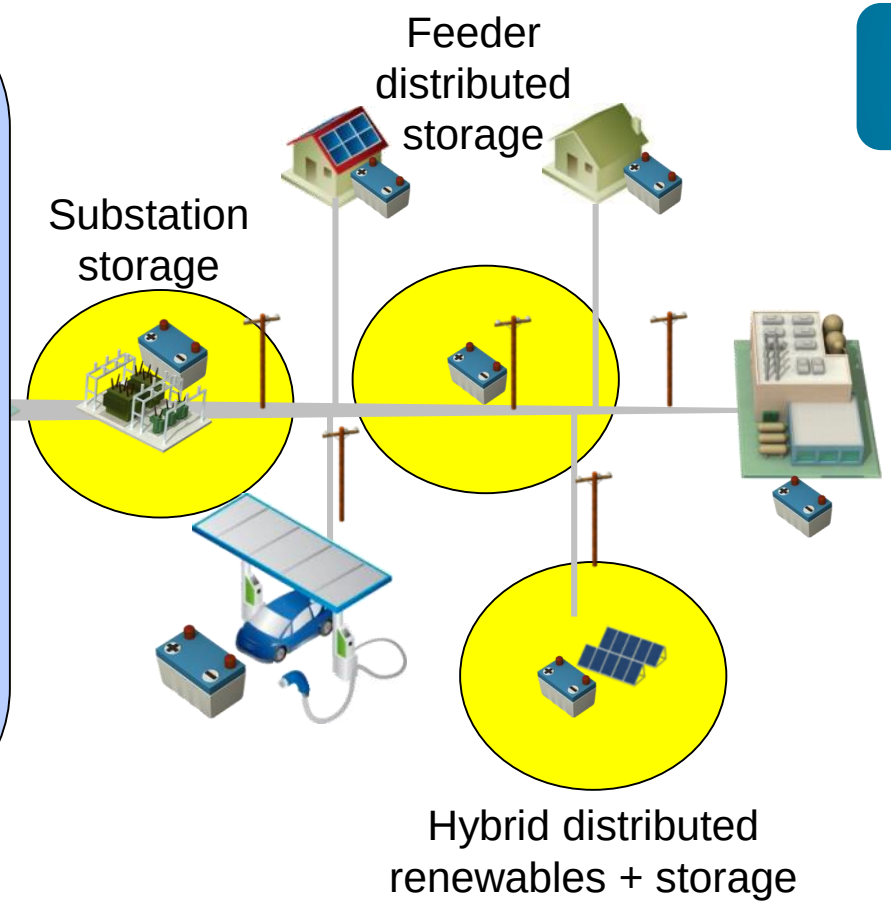
Bulk storage may complement generators or transmission assets

Energy Storage Applications – Distribution

Distribution-Connected Storage

May provide:

- Virtual distribution capacity
- Enhance power quality
- Resiliency / backup power / microgrid
- **Upstream transmission impacts – either costs or benefits**



Distribution Storage: 10kW to 10MW

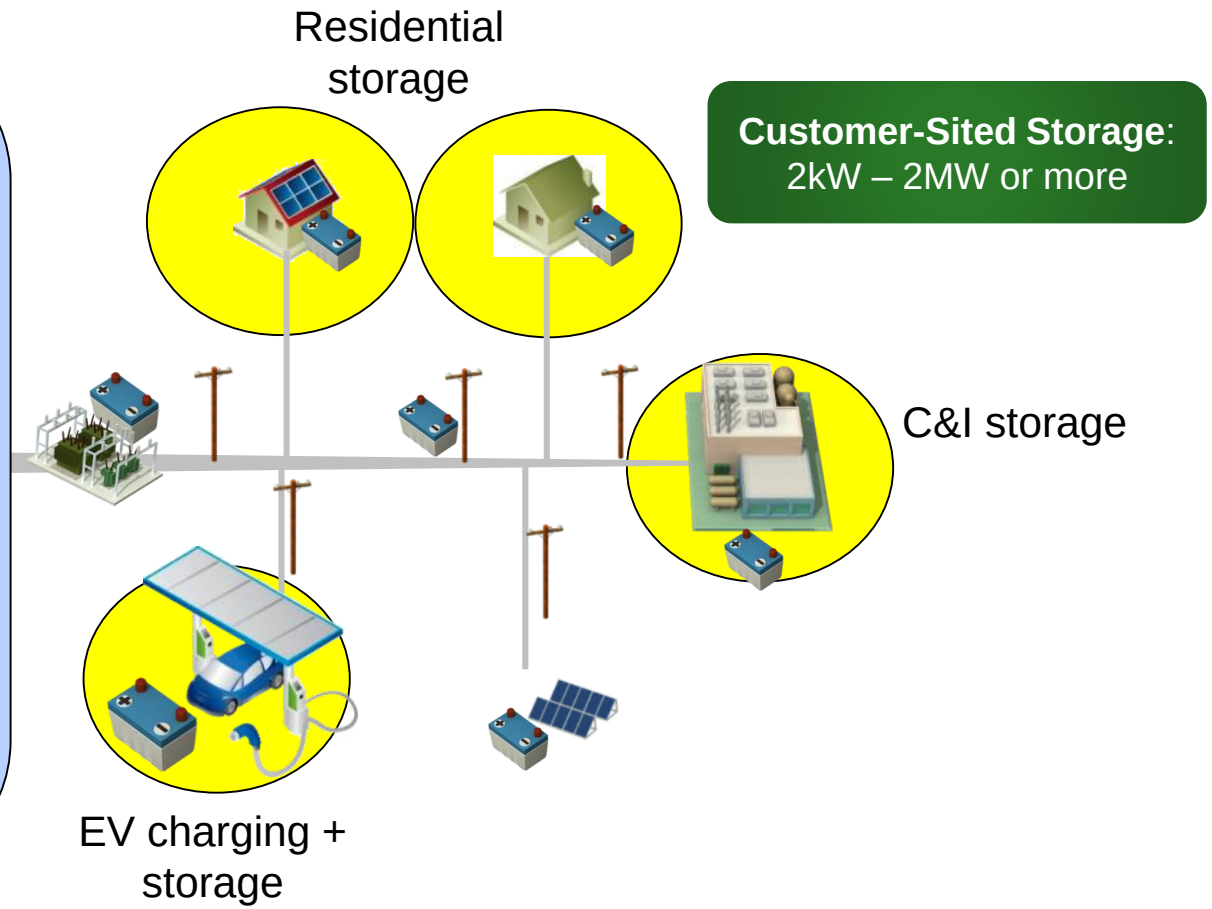
May be able to stack distribution and upstream transmission services

Energy Storage Applications - Customer

Customer-Connected Storage

May provide:

- Customer bill savings
  - Retail time-of-use tariff energy shifting
  - Demand charge management
- Backup power / customer microgrid
- **Upstream T&D impacts – either costs or benefits**

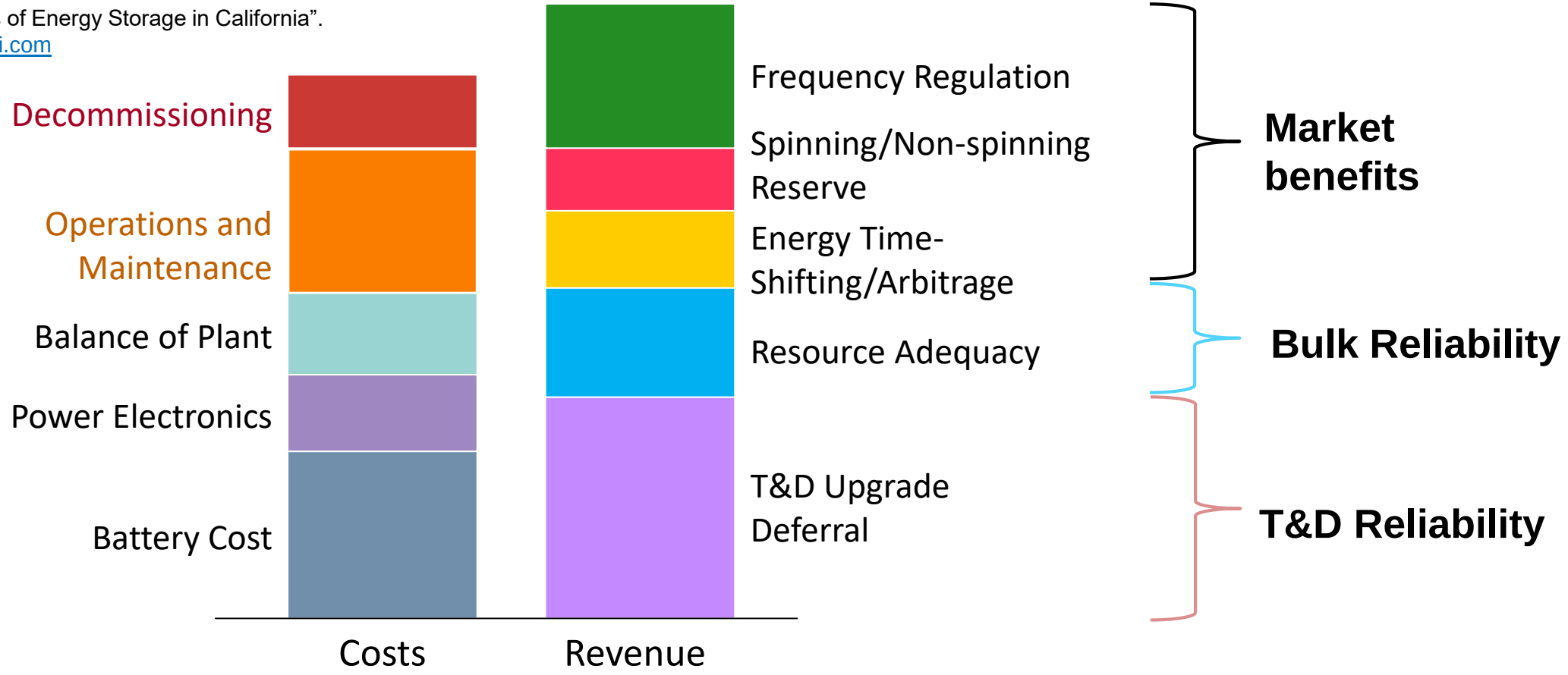


May be able to provide upstream grid services via utility programs

Multiple-use value stacking may support cost-effectiveness

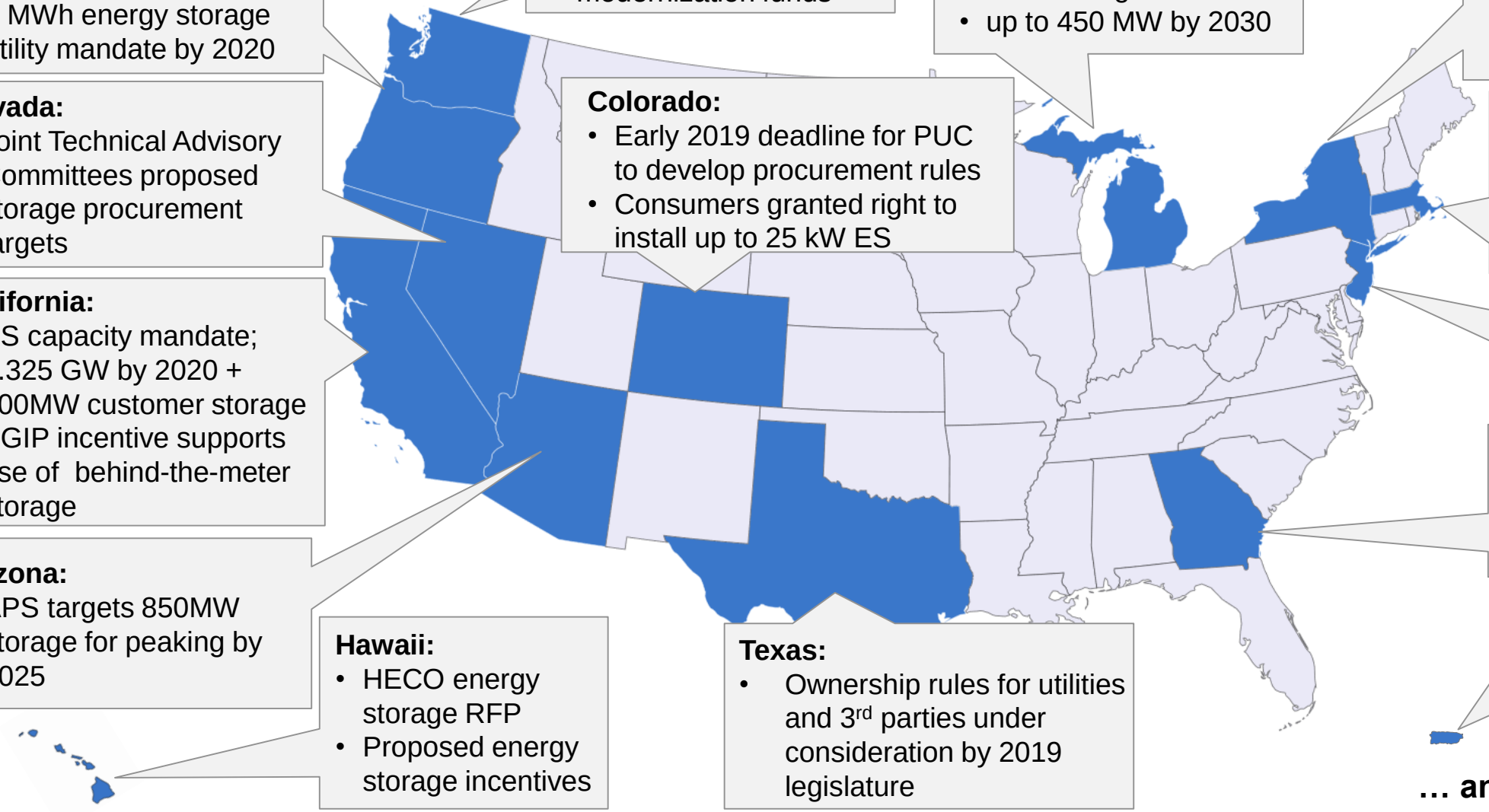
*For Illustration Only

*Source: Cost-Effectiveness of Energy Storage in California". EPRI 3002001162 www.epri.com



Monetizing storage is still challenging from a regulatory perspective
Value stacking is still primarily in demonstration phase

Key State Activities Driving Storage Deployments



Washington:
- Clean Energy Fund grid modernization funds

Michigan:
- State RPS: 100 MW / 4 hour storage block
- up to 450 MW by 2030

New York:
- 1500MW storage by 2025
- 3000MW by 2030
- REV grid modernization
- Rebate incentives (2019)

Oregon:
- 5 MWh energy storage utility mandate by 2020

Colorado:
- Early 2019 deadline for PUC to develop procurement rules
- Consumers granted right to install up to 25 kW ES

Massachusetts:
- 200MWh storage by 2020, 1GWh by 2025
- DOER Energy Storage Initiative

Nevada:
- Joint Technical Advisory Committees proposed storage procurement targets

California:
- ES capacity mandate; 1.325 GW by 2020 + 500MW customer storage
- SGIP incentive supports use of behind-the-meter storage

New Jersey:
- 600MW storage target by 2021, 2GW by 2030

Georgia:
- 50MW storage plan in 2019 Integrated Resource plan

Arizona:
- APS targets 850MW storage for peaking by 2025

Hawaii:
- HECO energy storage RFP
- Proposed energy storage incentives

Texas:
- Ownership rules for utilities and 3rd parties under consideration by 2019 legislature

Puerto Rico:
- Mandate storage to regulate frequency and manage ramp rates

… and many more in motion

Remaining Challenges and Research Priorities

EPRI Energy Storage Research Priorities

OPERATIONAL DATA

Track record is short

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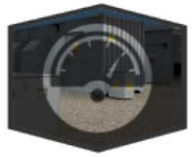
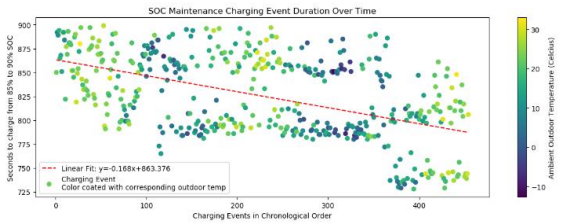
Understanding real-world performance and reliability is critical for investment





MODELING AND TOOLS

Storage serves new roles and may stack applications

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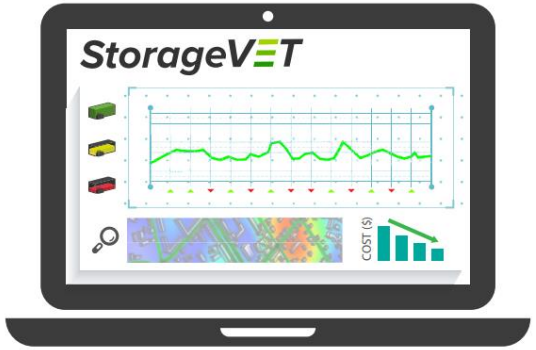
Decision-makers require new tools and methods



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IMPLEMENTATION

Storage is new and complicated

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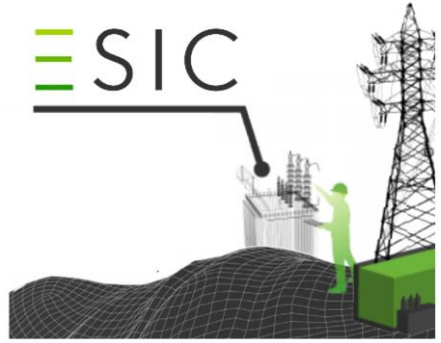
Industry needs best practices for procurement, deployment, control, and safety



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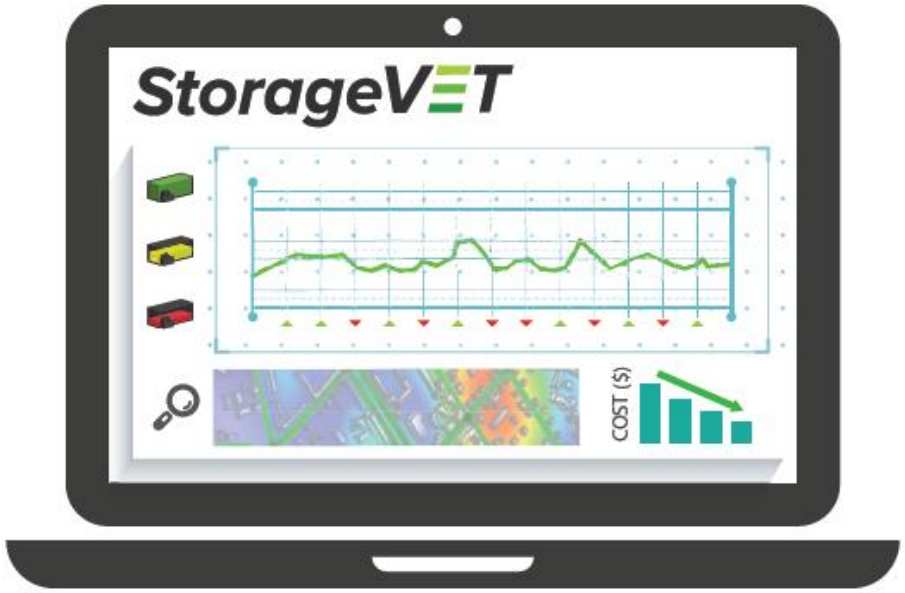
New methods and tools important for storage valuation

Storage Value Estimation Tool (StorageVET®) is a free, publicly available energy storage project valuation tool informing decision-makers across the electric grid

StorageVET Uses:

- Explore site-specific project value with stacked services
- Communicate results across multiple stakeholders
- Customize cases:
  - All grid services
  - All storage technologies and sizes
  - Any grid location
- Identify high value locations



Get started at storagevet.com

ESIC
ENERGY STORAGE INTEGRATION COUNCIL

A forum advancing the integration of energy storage systems through open, technical collaboration

ESIC Stakeholders

Publicly Available ESIC Resources

- Energy Storage **Implementation** Guide
- Energy Storage **Cost** Template and Tool
- Energy Storage **Modeling** Bibliography
- Energy Storage **Technical Specification** Template
- Energy Storage **Safety** Guidelines
- Energy Storage **Test Manual**
- Energy Storage **Commissioning** Guide
- Energy Storage **Request for Proposal** Guide
- **Common Functions** for Smart Inverters V4
- **StorageVET** and Supporting Documentation

Available at **www.epri.com/esic**

Email esic@epri.com to join the 1800+ industry collaborators

Energy Storage Publicly Available Resources

- EPRI – http://www.epri.com/Pages/Default.aspx
- Energy Storage Integration Council, Publicly available guidelines, tools, and templates – http://www.epri.com/esic
- Storage Value Estimation Tool (StorageVET) – http://www.storagevet.com
- DOE/EPRI Energy Storage Handbook – SANDIA REPORT SAND2015-1002 http://www.sandia.gov/ess/publications/SAND2015-1002.pdf
- Energy Storage Technology and Cost Assessment: Executive Summary. EPRI, Palo Alto, CA: 2018. 3002013858. https://www.epri.com/#/pages/product/000000003002013958/
- Recycling and Disposal of Battery-Based Grid Energy Storage Systems. EPRI. Palo Alto, CA: 2017. 3002006911. https://www.epri.com/#/pages/product/000000003002006911/
- DOE OE Energy Storage Monthly Codes and Standards Update – https://www.sandia.gov/energystoragesafety-ssl/codes-standards/status-of-codes-and-standards/
- NFPA 855, Standard for the Installation of Stationary Energy Storage Systems – https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855
- International Fire Code (IFC) – https://codes.iccsafe.org/content/IFC2018
- Cost-Effectiveness of Energy Storage in California– http://www.cpuc.ca.gov/NR/rdonlyres/1110403D-85B2-4FDB-B927-5F2EE9507FCA/0/Storage_CostEffectivenessReport_EPRI.pdf
- DOE Energy Storage Database – http://www.energystorageexchange.org/
- DOE/Sandia Labs Energy Storage Program – http://www.sandia.gov/ess/

Together…Shaping the Future of Electricity

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