ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage: Opportunities and Challenges

Haresh Kamath
EPRI Program Manager
for Energy Storage and DG

Bay Area Battery Summit
November 3, 2015

© 2015 Electric Power Research Institute, Inc. All rights reserved.

Together…Shaping the Future of Electricity

EPRI's Mission

Advancing safe, reliable, affordable, and environmentally responsible electricity for society through global collaboration, thought leadership and science & technology innovation.

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Growing Interest in Energy Storage

Tesla PowerWall Home Battery

"Improvements in batteries and distributed generation could partly or completely eliminate some customers' usage of the power grid…"

– Morgan Stanley Blue Paper, Solar Power & Energy Storage *July 28, 2014*

"…[the] solar generation/battery storage combination is currently an order of magnitude too expensive to cause much grid defection."

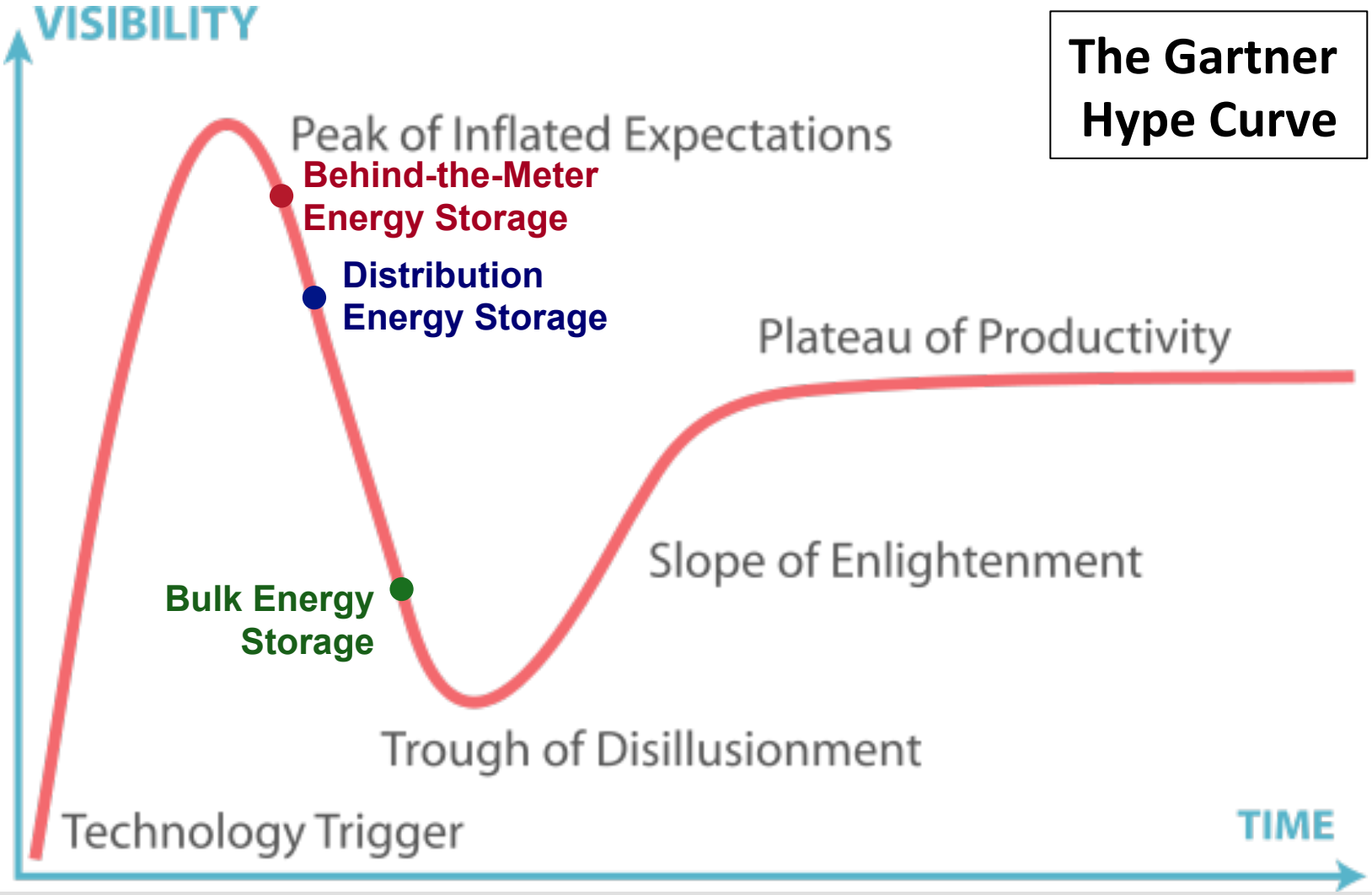
– Moody's Investor Service, "Batteries are Coming but Utilities are not Going Away" *January 6, 2015*

Where are the real opportunities for energy storage in the next 5 to 10 years?

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Storage is near the peak of the hype cycle

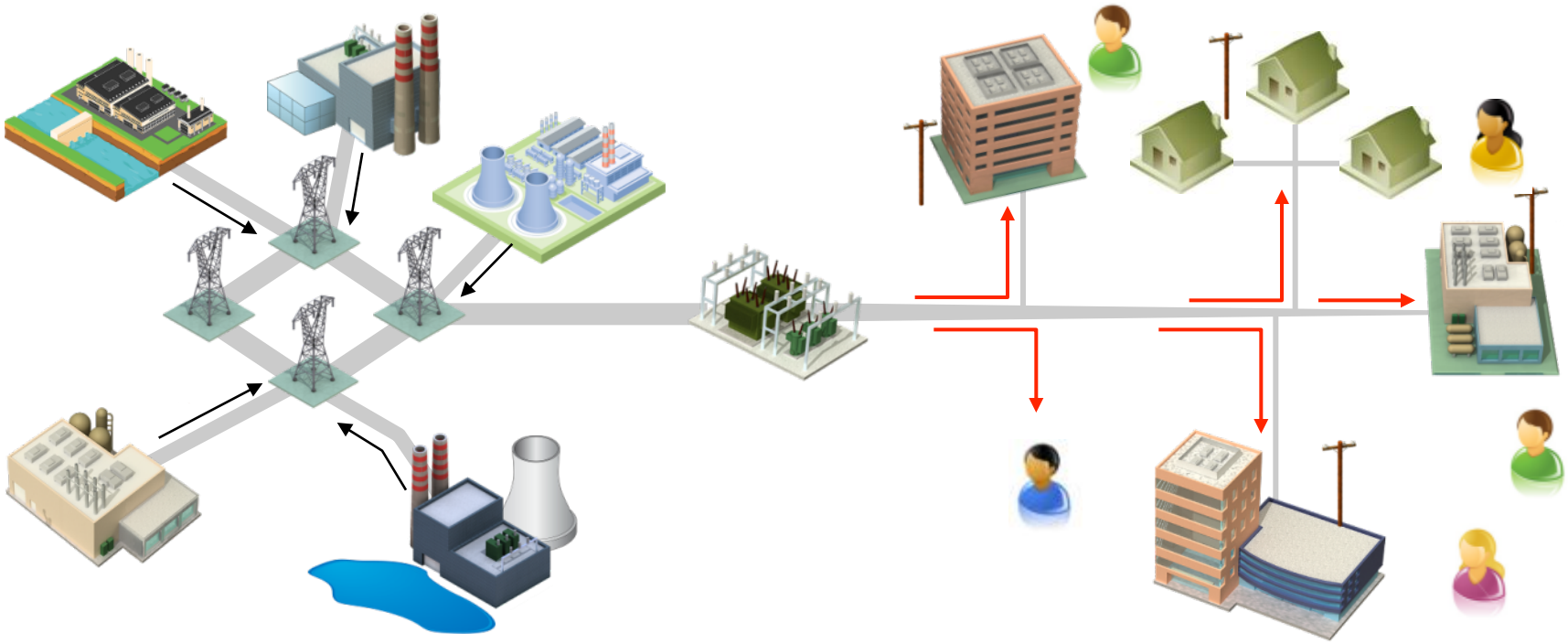


Where are the real opportunities for energy storage in the next 5 to 10 years?

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Today's Power System



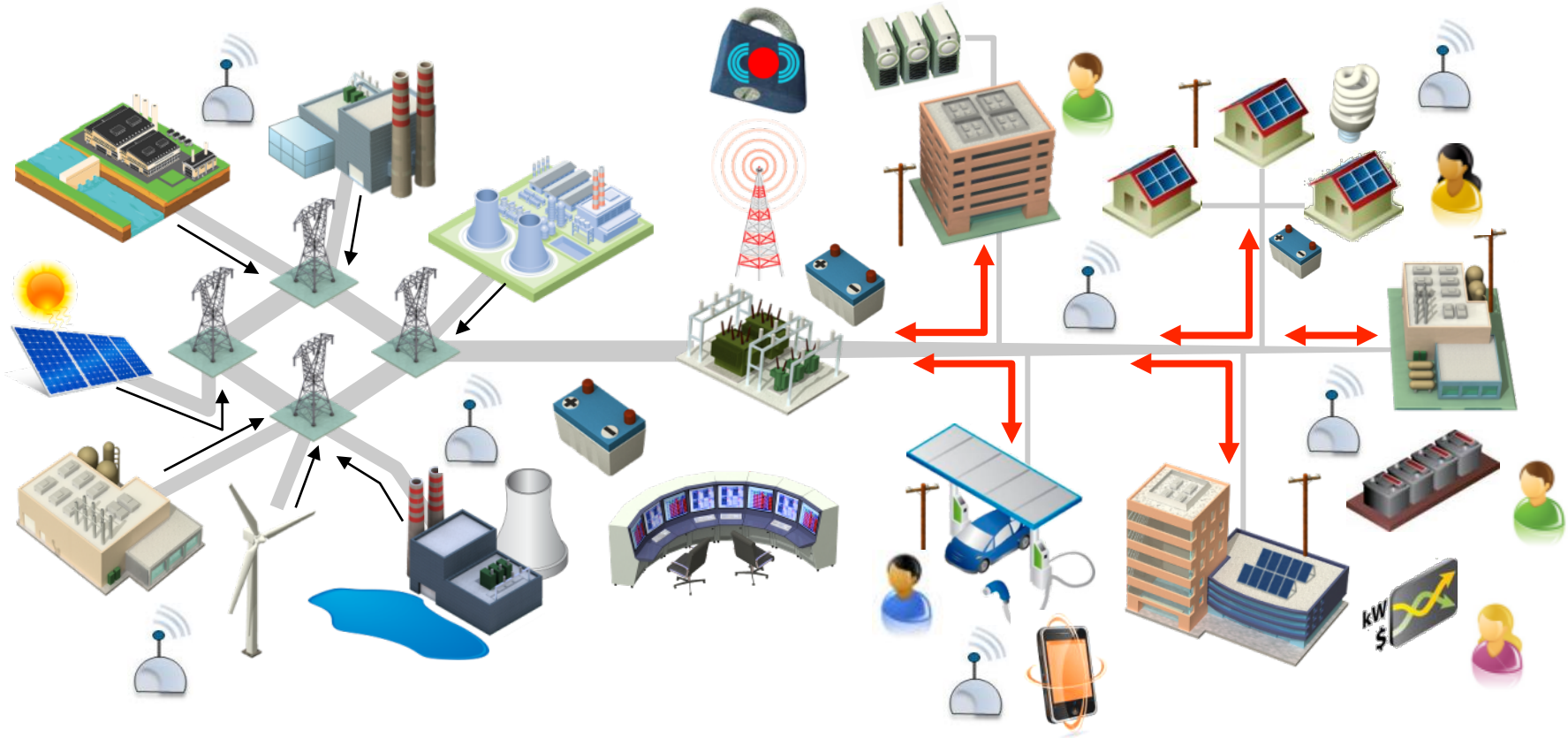
Generation **Delivery** **Customer**

Base Load Generation + Load Following Generation +/– Bulk Energy Storage = Customer Demand – Interruptible Load DR

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Transformation of the Power System

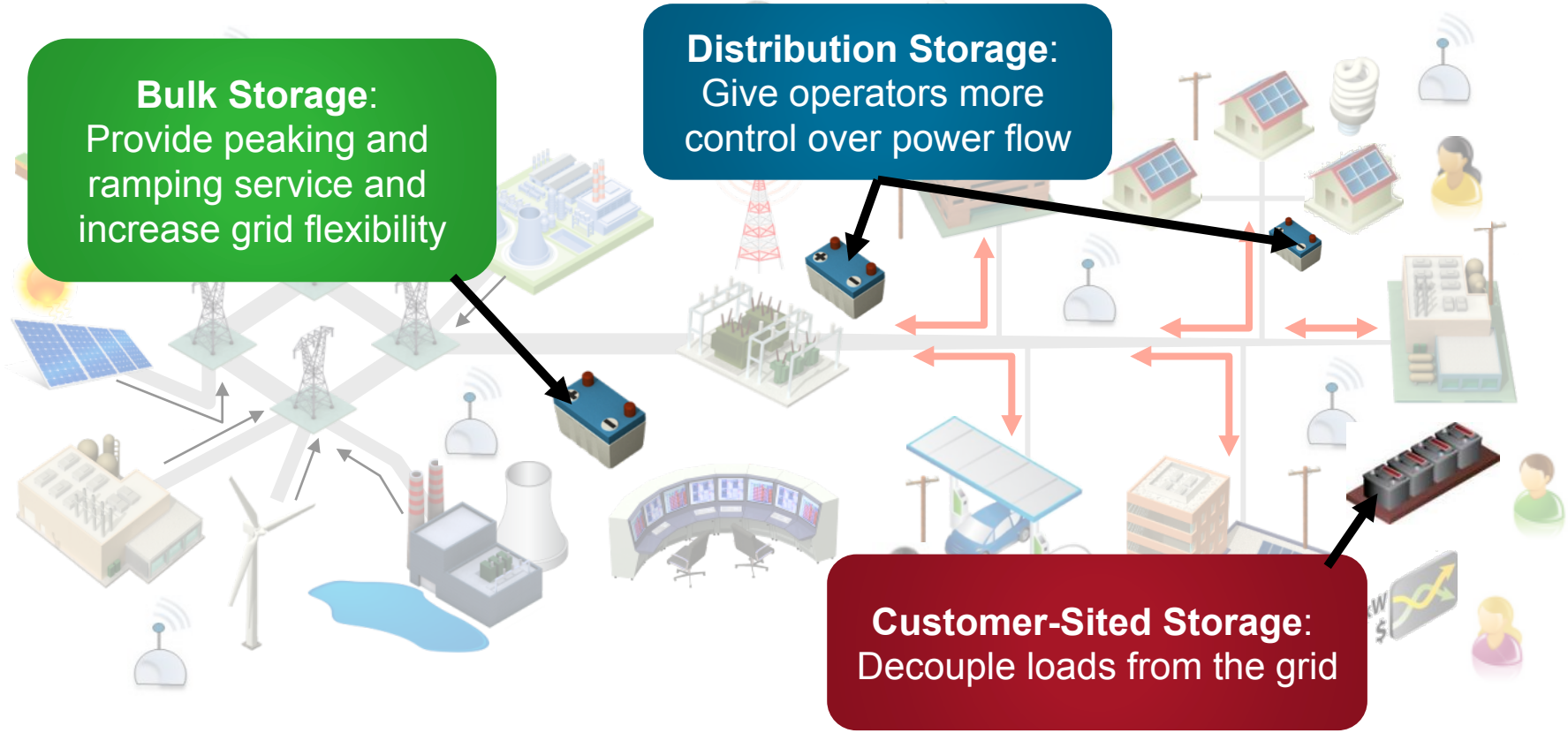


A Highly Interconnected Power System that Optimizes Energy Resources

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Transformation of the Power System



Energy storage can play key roles across the grid

© 2015 Electric Power Research Institute, Inc. All rights reserved.

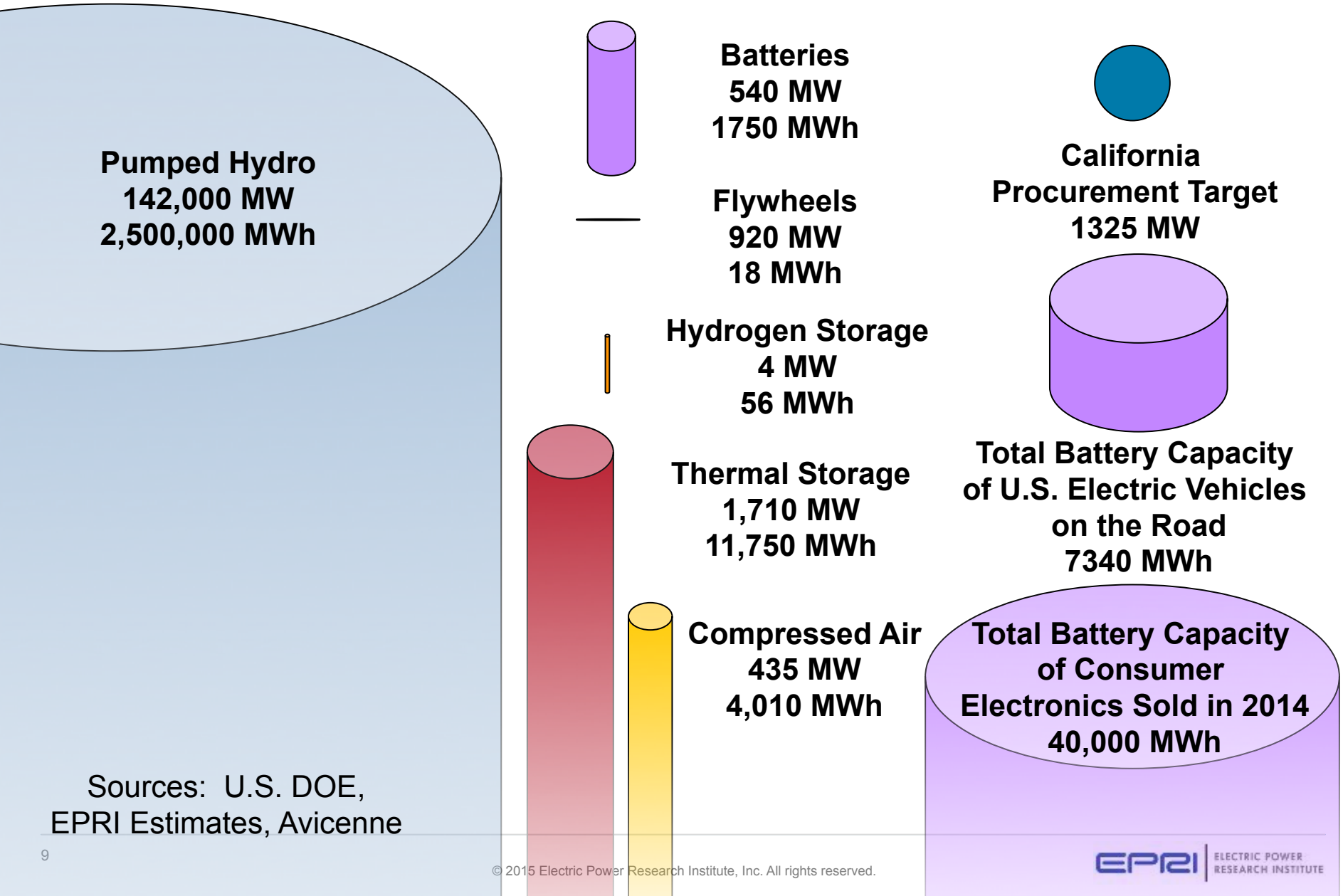
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage: A Flexible Asset for the Grid

- The grid is a just-in-time supply system, designed to deliver energy as it is produced
- Storage can act as a buffer, making the grid more flexible to accommodate more variable renewable generation
- Storage can provide temporary local power, increasing grid reliability and resiliency
- Storage can improve asset utilization on the grid, reducing the potential for future rate increases

© 2015 Electric Power Research Institute, Inc. All rights reserved.

Total Deployed Grid Storage Worldwide, April 2015



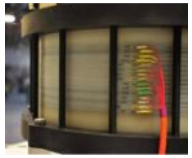
Sources: U.S. DOE, EPRI Estimates, Avicenne

© 2015 Electric Power Research Institute, Inc. All rights reserved.

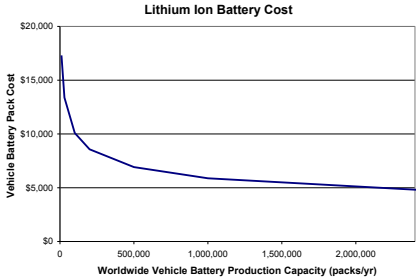
EPRI ELECTRIC POWER RESEARCH INSTITUTE

The historical challenges are fading

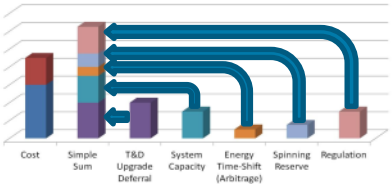
- Technical challenges
  - Performance
  - Life
  - Efficiency
- Economic Challenges
  - High Costs
  - Small Value Streams
- Regulatory Challenges
  - Lack of clear definition
  - Framework designed for existing grid



Advanced Technologies



Lower costs



New Business Models

Regulatory Rulings

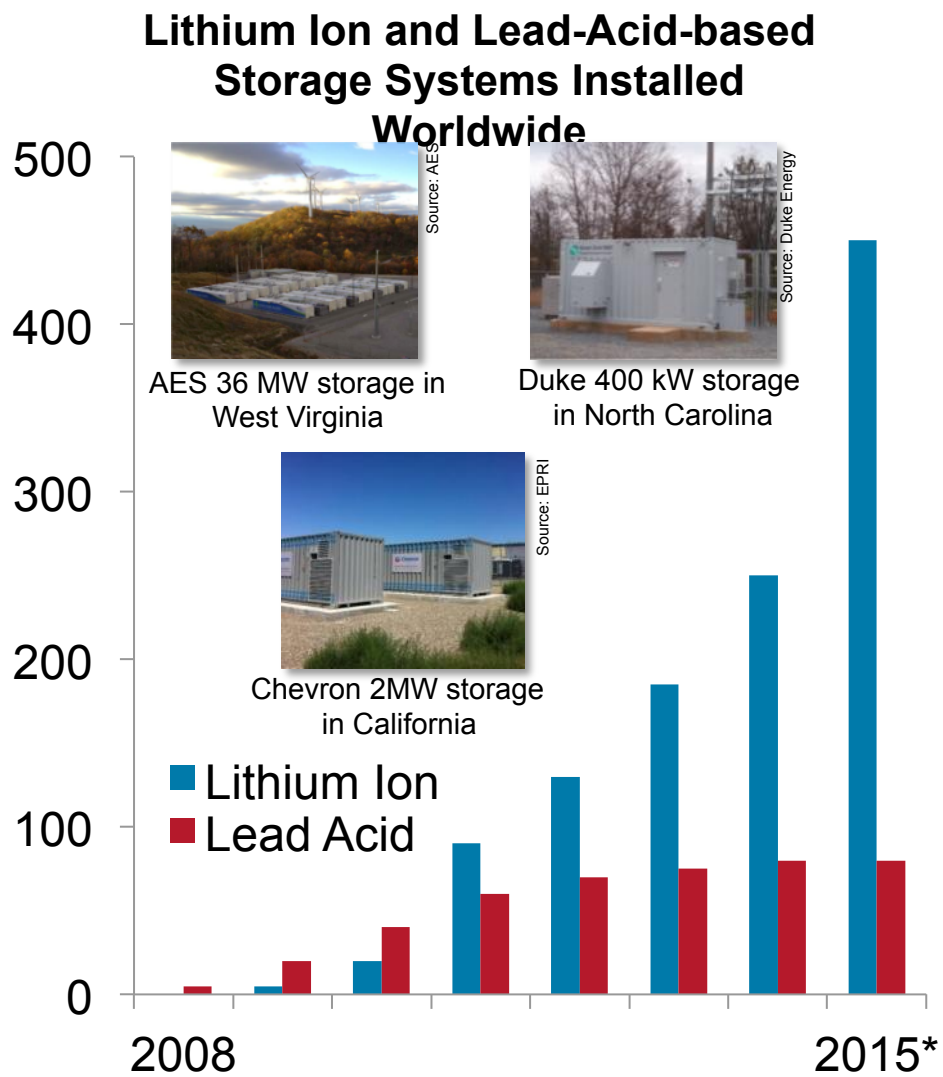
Legislative Action

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Deployment of stationary storage continues

- Investment in storage continues, particularly in lithium ion products for ancillary services
- Utilities are exploring options at the transmission and distribution level
- Some developers are installing systems on the customer side of the meter



Source: U.S. DOE, EPRI Estimates

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Regulatory and Policy Developments

- New storage legislation coming about in Germany, Japan, South Korea, Ontario, California, Puerto Rico, New York, New Jersey…
  - Most storage legislation creates incentives for customer-side storage
  - California has mandated 1.325 GW of utility energy storage by 2020

- FERC Rulings 755, 784, 792 open new doors for storage in electricity markets

© 2015 Electric Power Research Institute, Inc. All rights reserved.

Many challenges remain

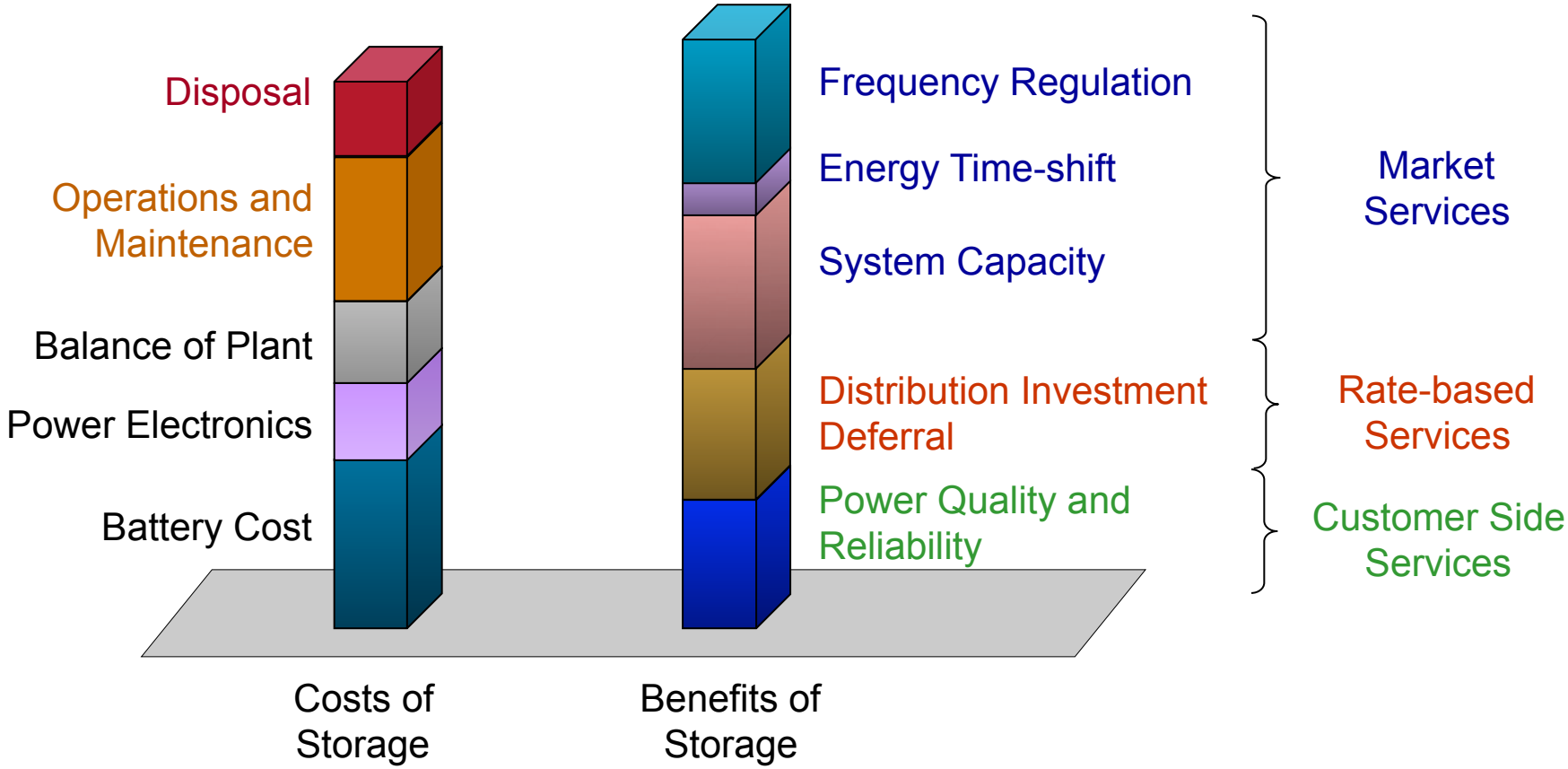
- Costs and performance factors of technology solutions must be better understood
- Tools for understanding the value and grid impacts of storage are still in development
- Grid-ready technology solutions are the exception, not the rule
- Deployment, integration, operations, maintenance, and disposal are still major unknowns
- Deployment of storage technology can be better integrated into utility planning and operations processes to improve reliability and reduce costs

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Analyzing the Value of Storage

For Illustration Only



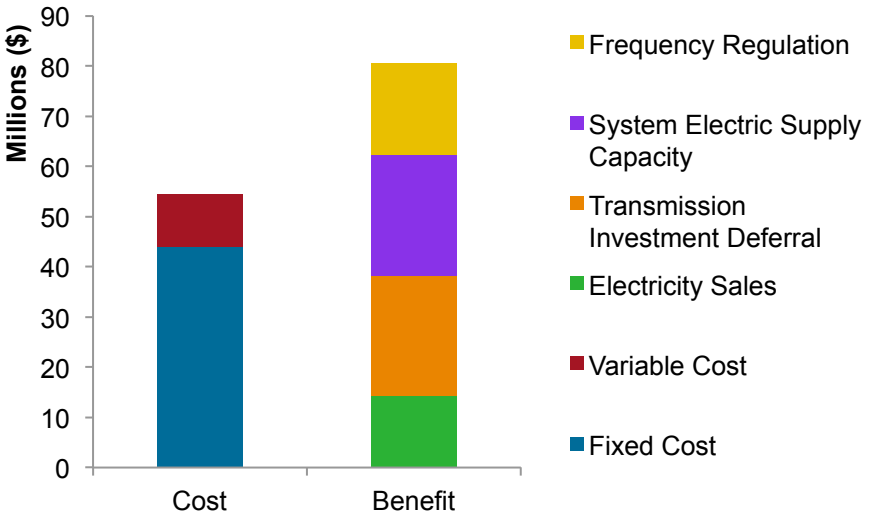
Developing a business case usually requires stacking multiple benefits

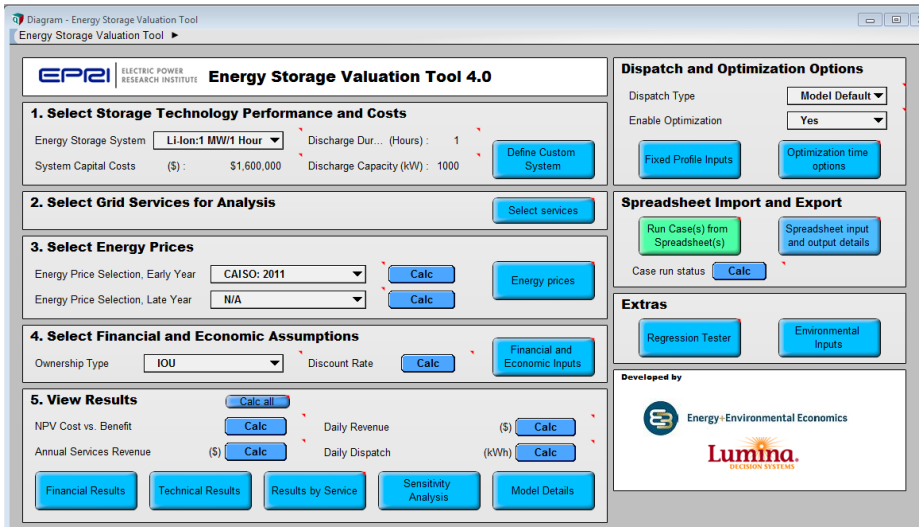
© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Developing analysis tools

Heavy efforts are underway at utilities and leading analysts, to develop standard analysis methodologies to understand value and grid impacts of storage, and inform utilities, regulators and the general public





EPRI Energy Storage Valuation Tool 4.0

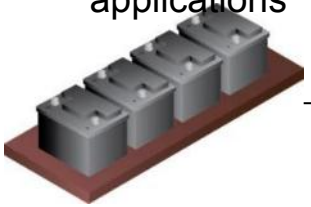
© 2015 Electric Power Research Institute, Inc. All rights reserved.

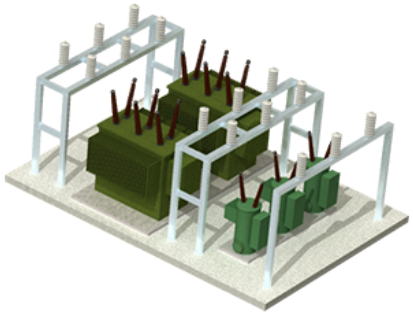
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Facilitating Grid-Ready Energy Storage Systems

Underlying Technologies

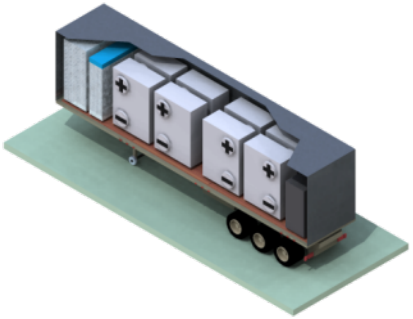
- Exploring technology tradeoffs
- Optimizing technology for utility applications





Grid integration

- Establishing best practices for siting and permitting
- Standardizing the interface with the grid
- Modeling and analyzing the effects on the grid



Communications and Control

- Defining interoperable protocols
- Developing operational and dispatch algorithms

Power Conditioning

- Establishing appropriate operations and control
- Ensuring efficient and reliable operation

Deployable Product

- Ensuring safety and reliability
- Understanding cost and performance
- Simplifying procurement and operation through standardization of specification and interfaces

© 2015 Electric Power Research Institute, Inc. All rights reserved.

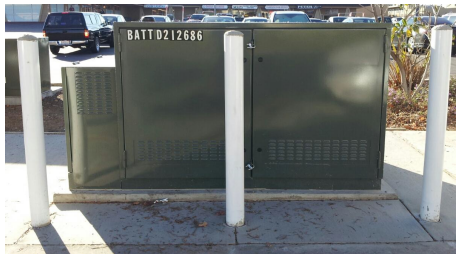
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage System Demonstrations

Multiple Chemistry…Multiple Application…Various Size

402kW/282kWh; Sodium Nickel; Duke

250kW/1MWh; Lead-Carbon; PNM Resources



25kW/50kWh; Lithium Ion; Microgrid – SDG&E

9MVA/32Wh; Lithium Ion; Wind – SCE

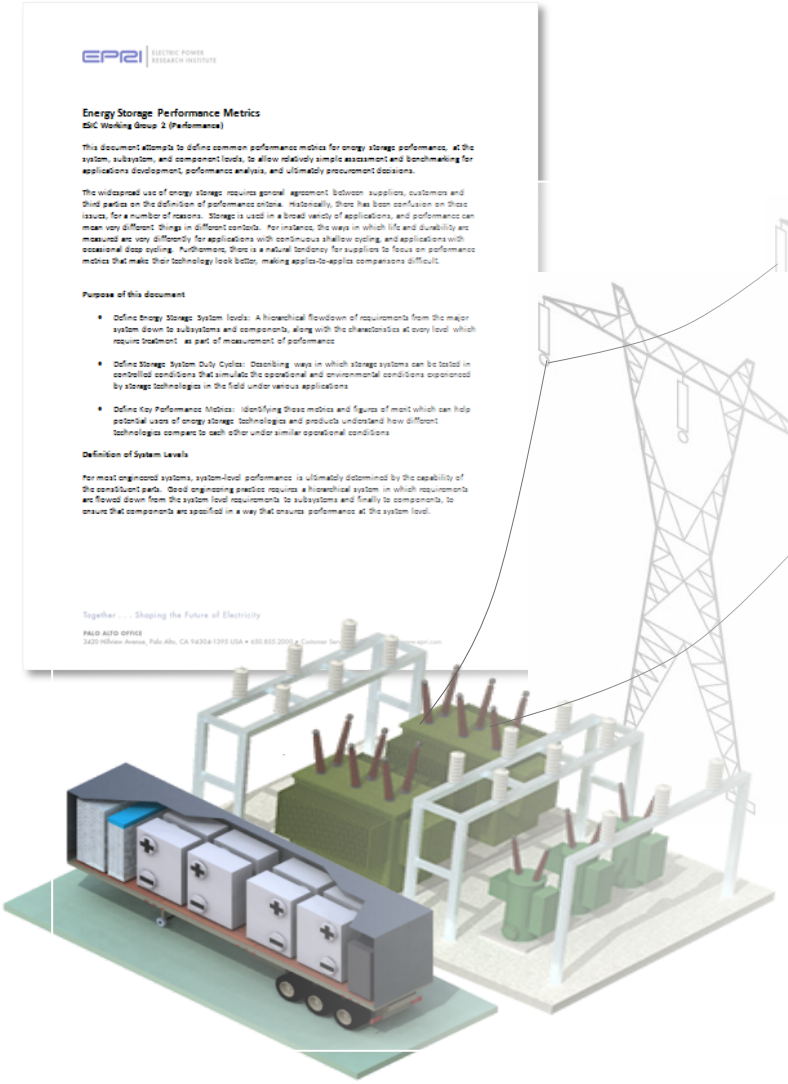
- System safety a critical consideration – need more operational experience to understand fire suppression requirements
- Control logic for multiple dispatch algorithm is in its infancy
- Firmware/Software upgrade/maintenance impacts reliable operation
- Mini-system testing will be critical for early deployments

Battery technology is mature but system integration and operational experience are still lacking

© 2015 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage Integration Council (ESIC)



- ESIC is a technical forum to discuss issues and identify gaps related to grid storage integration
  - Addresses the imminent deployment of storage in distribution contexts
  - ESIC is necessary work to establish best practices and standards
    - Facilitate conversations between stakeholders
    - Bring up the necessary questions and find someone to answer them
    - Prevent bad stuff from happening
  - Seeking participation and leadership from utilities, vendors, integrators, and other stakeholders

Contact ESIC@EPRI.COM for more information!

© 2015 Electric Power Research Institute, Inc. All rights reserved.

Together…Shaping the Future of Electricity

© 2015 Electric Power Research Institute, Inc. All rights reserved.

ELECTRIC POWER RESEARCH INSTITUTE