Energy Storage Market Overview
MADRI 3/3/2015

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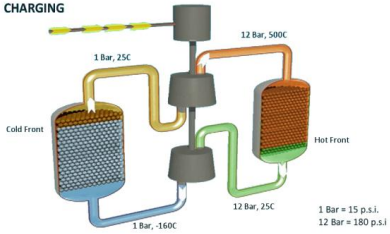
WIND | SOLAR | TRANSMISSION | STORAGE

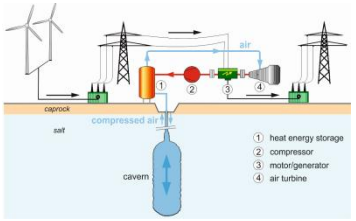
Storage Technologies

Over 100 Energy Storage Technologies

Flywheels



Thermal ES



CAES (Compressed Air ES)

Aqueous Sodium

Super Capacitors

Liquid Metal

High Temperature Sodium

Zinc Air

Flow Batteries

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Why Lithium Batteries

Chemical & Thermal Safety

Battery Safety

- Battery chemistry safety – **No internal thermal runaway**
- No hazardous materials, low MSDS of 0-1-0
- UL-listed Cells
- Non-toxic electrolyte

"The reduced peak of self-heating rate of LiFePO4 based cells makes them the safest cell Li-ion batteries on the market today"
-Sandia National Laboratories 2012

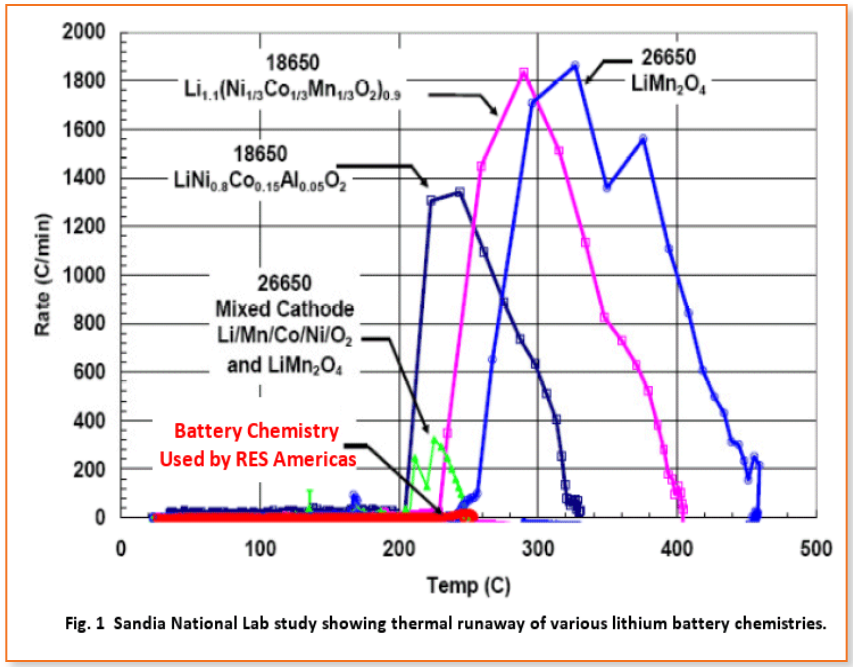


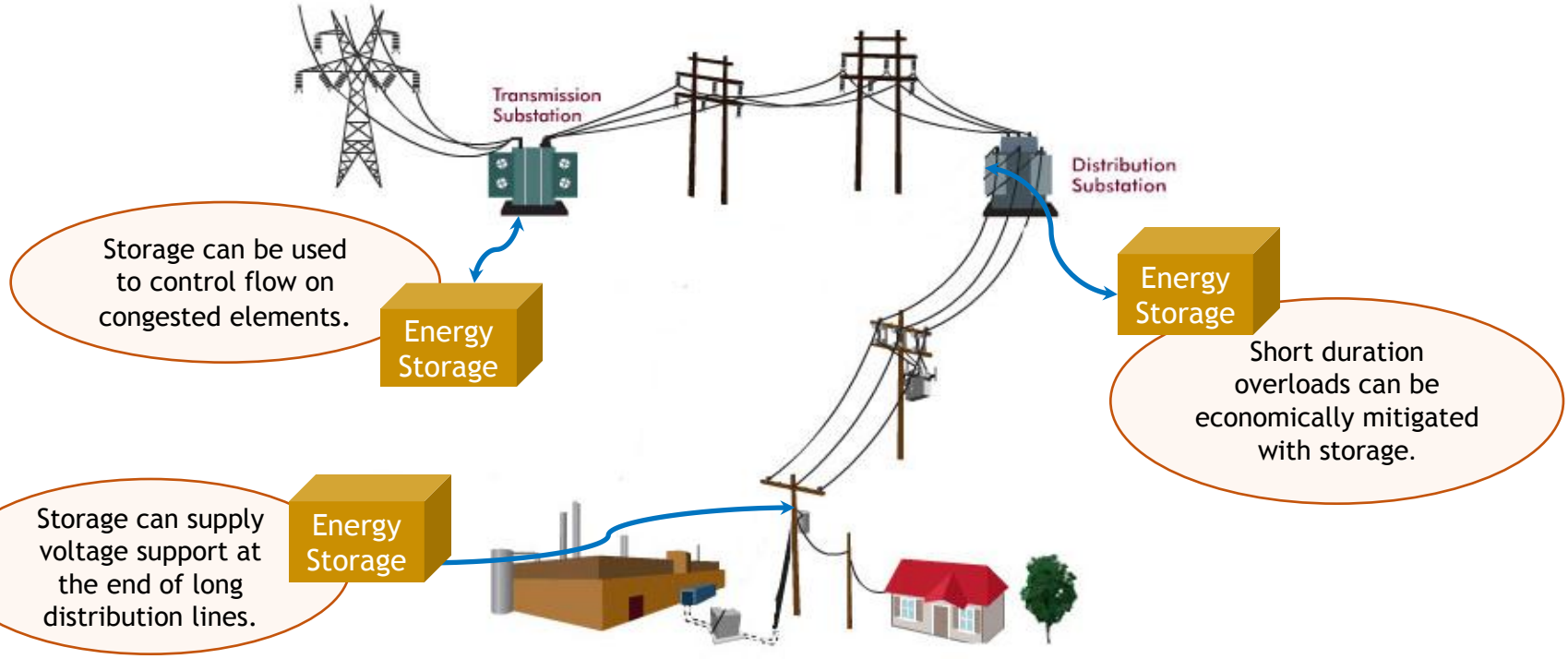
Fig. 1 Sandia National Lab study showing thermal runaway of various lithium battery chemistries.

Storage Applications

Ancillary Services

- Frequency Regulation
  - Driven by FERC Order 755
    - Two-part payment
    - Why PJM
- Order 784 for non-markets
  - Self-supply of balancing services
- Decrease in reserve requirements = net decrease in cost to load
- The right rules allow for merchant project development

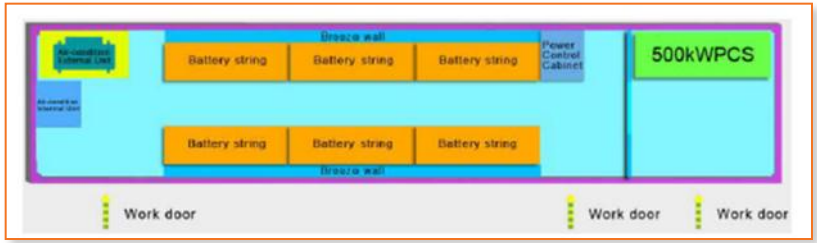
Distribution & Transmission Upgrade Deferral



Values	Benefits
▪ Reduce cost of infrastructure upgrades	▪ Reduces risk of upgrade ▪ Modular ES may be moved as required ▪ Reduces visual, environmental, & community impacts

Microgrid & Outage Mitigation

- Glacier, WA. RES' first distribution deferral / microgrid project. COD July 2015.
- 500kW/1.1MWh Mobile Energy



Values	Benefits
▪ Reduces outage cost to customers ▪ Increases grid resiliency, reduces risk of storm or terroristic actions	▪ Additional value on top of distribution deferral ▪ Storm mitigation ▪ Could support critical facilities

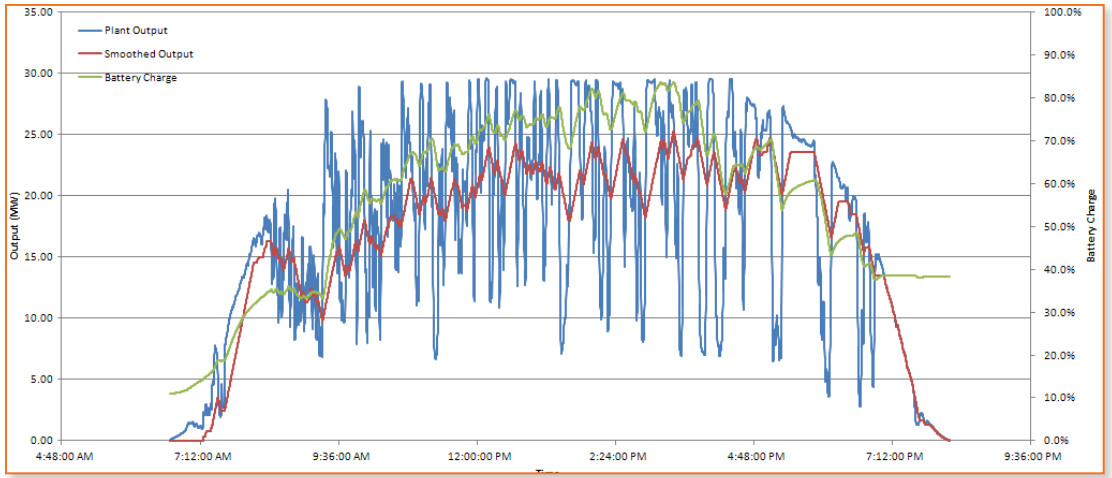
Storage as Wires

- Reliability: Peaking Requirements
  - Stranded Assets
- Regulated Cost Recovery for Transmission Applications
  - Western Grid
- Regulated Cost Recovery for Distribution Applications
  - Jurisdictional Considerations
  - Deregulated vs. Regulated Markets
- Multiple Value Streams

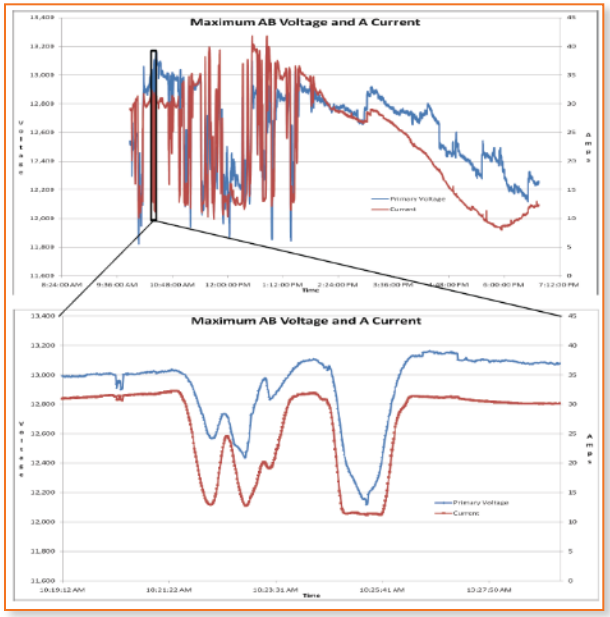
Storage as “Capacity”

- I’m not going there
- Is there a “peak” or “flexible” value for “capacity”?
  - What is the duration?
  - Reduction of out-of-market payments
- California RA
- PJM Capacity Performance
  - Maximizing the value and utilization of intermittent resources
  - CPP Compliance
- Multiple Value Streams

PV / Wind Ramp Control



Webberville 30MW PV on a Partially Cloudy Day



Rooftop PV causing Voltage Fluctuations on local Distribution. SDG&E Rate Case 2012

Values

- Mitigation of PV DG variability on distribution (voltage fluctuations)
- Ramp control for large grid PV projects

Benefits

- Much faster than available carbon based balancing
- Improve power quality
- Eliminate upstream current flow

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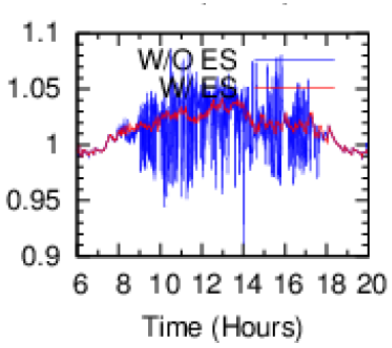
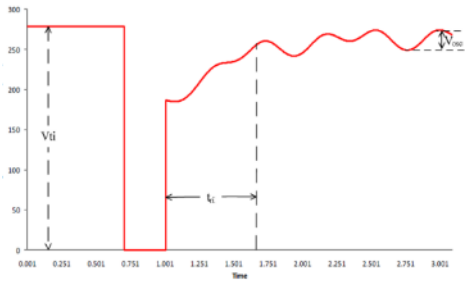
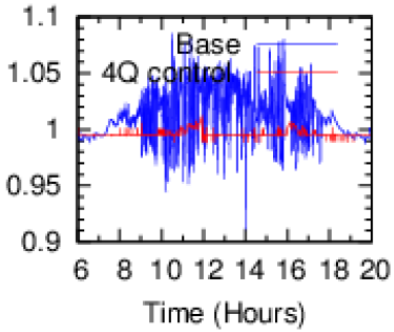
Power Quality

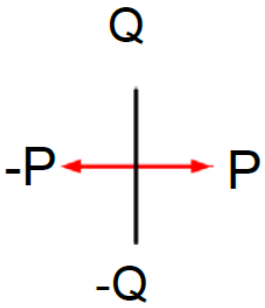
Full Active & Reactive Power Control

- Flicker mitigation
- Voltage transients, sags, swells
- Power factor correction
- Phase balancing
- Oscillation dampening









Values

- Reduce equipment heating, protective device malfunction, & catastrophic failure
- Increase efficiency a improved utilization of grid assets

Benefits

- Compliance with utility interconnection requirements
- Reduces need for distribution upgrades related to DG, Grid PV, faults, & blackouts

Additional Energy Storage Services

- Spinning reserve
- Wind integration fee mitigation
- Reducing resource adequacy requirements
- Volt/VAR power quality services
- Replace dynamic VAR in renewable energy plant
- Demand management
- Power factor control
- Phase balancing
- Mobile locations / seasonal load relief

Policies for Storage Development

Key Policies

- Storage should be treated as storage and not “forced” into a simple supply or load construct for modeling, interconnection, or billing
- A single energy storage facility should be eligible to provide more than one service
- All benefits of energy storage should be quantified: environmental, power quality, grid resiliency, flexibility, & the ability to better integrate renewables
- Storage should be [properly] modeled in utility IRPs/ERPs

Thank you

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