Battery Storage: “Swiss Army Knife” of the Grid

Jeff Plew – Director of Development
NextEra Energy Resources, LLC
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NextEra Energy is comprised of two primary businesses utilizing a common platform and supported by several key subsidiaries.

- Fortune 200 company
- $76.6 B market capitalization
- $97.8 B in total assets
- Ranked #1 “Worlds Most Admired Companies”
- Partnership with

- The world leader in electricity generated from the wind and sun
- 149 operating assets in 33 states and Canada
- 18 GW in operation including over 125 MW of battery storage

Core Values
Commitment to Excellence / Do the Right Thing / Treat People with Respect
Agenda

• Market Overview and Technology Trends
  • T&D Grid Applications
  • Storage Project Examples
  • Additional Considerations
Industry estimates are that 4.7 GW of utility-scale storage and 2 GW of behind-the-meter storage will be installed in 2018-2022.

Energy Storage is poised for a rapid acceleration of installed capacity over the next 5 to 7 years, driven by flexibility in design and applications.

Energy Storage Market (annual)(1)

Incremental Capacity (MW)

Incremental Capital Deployed ($ B)

Utility-Scale – Primary Application
- Long-Duration Peaking Capacity (8+ hours)
- Regular, Cycling Peaking Capacity (4-8 hours)
- Peaking Capacity (1-4 hours)
- Occasional Peaking Capacity (1-4 hours)
- T&D Deferral
- Frequency Regulation

Behind-the-Meter – Primary Application
- Grid Services (Utility contracted)
- Capacity (Utility contracted)
- Coincident Peak Management
- Demand Response
- Demand Charge Management

1) Greentech Media
Unprecedented tax credit visibility past 2020 in wind and solar driving increased renewable build-out; Storage can be a key part of this growth and maturity

**ITC and PTC Extension**

**Wholesale Energy Prices**
- Cheap wind and solar will create economic demand
- Customer desire for green energy may also be a driver

**Storage Opportunities Created**
- Arbitrage
- Curtailment and congestion relief
- Increase need for frequency regulation (but a limited 2-3 GW market)

**Capacity Products**
- Renewables are cost efficient in many jurisdictions, but intermittent
- Capacity applications will happen with cost improvements, just a matter of “when” (4-8 hour peakers)

**Storage Markets to Pursue**
- Base load energy through storage and renewable joint dispatch
- Flexible capacity opportunities with distributed storage applications (1-100 MW)
While ancillary services markets drove initial growth in storage, longer duration applications are expected to grow significantly through 2021 and beyond.

The iPhone is Analogous to Storage Disruption

Eleven years ago, no one owned an iPhone; 11 years from now, cheap storage will disrupt how we consume electricity.
Energy storage is poised to become an integral part of the energy sector, due to cost declines associated with manufacturing scale and continued R&D efforts.

What is Driving Energy Storage Growth?

• **Storage provides customized and adaptable solutions**
  - Highly flexible resource capable of performing multiple roles
  - Regulatory policy advancements along with fast ramping capability will help enable integration of more renewables
  - Simpler siting makes storage a viable alternative to new fossil generation and transmission

• **Declining costs through continuously improving technology and scale of manufacturing**
  - New technologies and controls play a large role in driving demand for energy storage

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Lithium-ion storage technology continues to be the market’s preferred technology for today’s grid applications.

**Market Maturity of Grid Storage Technologies**

Evaluation of traditional technologies and alternative technologies (sodium sulfur, flow) for longer duration applications will continue.
In 2015, electric vehicles accounted for 35% of lithium-ion consumption versus 2% in 2005\(^{(1)}\)

**Evolution of the Li-ion Market\(^{(2)}\)**

The electric power industry will be a secondary beneficiary of the electric vehicle demand for lithium-ion batteries

1) The Battery Series Part 3: Explaining the Surging Demand for Lithium-Ion Batteries, Visual Capitalist

2) Energy Storage Deployment by application, Bloomberg New Energy Finance
Significant R&D amounts invested by the automotive sector has led to on-going battery density improvement.

**Technology Improvements – Energy Density**

Energy density improvements are primarily attributable to the redesign of batteries and addition of new chemistry variations.

Higher density both improves the battery cost and reduces the total system footprint.

1) Bloomberg New Energy Finance - Battery energy density improvements (July 2017)
The battery module cost declines we are seeing are similar to that seen in solar technology in recent years.

**Cost Learning Curve with Scale**

Under current projections based on public data, the $100/KWh module cost mark may be reached by 2025.

2) $m represents the historical cost decline for every cumulative doubling of produced module capacity
Two recent FERC rulings will contribute to efforts in opening up additional market participation and interconnection opportunities for energy storage

Energy Storage Opportunities- FERC Order 841 and 845

- **FERC Order 841** requires ISO’s to wholesale participation models that account for the unique physical and operational characteristics of energy storage
  - Allows storage to more effectively participate in all ISO market products, increasing revenue potential while contributing to overall reliability
  - ISO/RTO compliance filing with FERC by 12/2/2018; implementation expected by December 2019
- **FERC Order 845** includes key provisions to allow storage to be integrated into existing projects easier than they can be today
  - New “Surplus Interconnection” provisions may enable expansion of an existing generating facility nameplate without an interconnection request
  - Reduced study time and costs, lower network upgrade costs when adding storage to existing wind, solar or fossil sites
  - Effective date in early 2019

FERC activities related to storage should support additional projects and opportunities in the near future
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Energy storage applications span multiple disciplines across the grid, but use case stacking is key to unlocking the full value of storage.

**Energy Storage - Grid Applications**

Storage can do many different things, but not necessarily all at once; design and location are key factors.
A seamless integration of the various components is critical to meet unique application requirements and realize cost effective operations and reliability value.

**Energy Storage – System Integration**

- Integration is a combination of hardware and software components, joined together to provide a seamless interface between the energy storage system and the grid.
- This includes:
  - Determining the optimal battery, inverter and transformer configuration.
  - Optimizing the containerization design of the system, HVAC and fire suppression systems design.
  - Developing software and communications to optimally dispatch the system while maintaining the system health and state of charge.
    - Includes the controls and design need for storage use-case “stacking” when providing multiple value streams.
Storage could displace a large portion of the sub-4 hour, >$40/MWh peaker market

**Peaker Replacement**

- **Replacing existing peakers**
  - Solar + storage or standalone
  Storage can offer a peaker replacement product competitive with the marginal cost of some expensive peakers

- **Storage should compete with new-build combustion turbine peakers as storage costs continue to decline; NYISO and CAISO in particular show near-term promise**

There is 100 GW of sub-4 hour peaker capacity with a marginal cost above $40/MWh; 40 GW of that has a marginal cost above $60/MWh

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1) Velocity Suite/EIA 2016; all daily dispatches of fossil fuel units above an annual heat rate of 9,000 Btu/kWh for sub-8 hour dispatches
Storage has the greatest opportunity to provide peaking capacity in areas with high load, transmission congestion, or high permitting costs.

**Storage as a Peaking Resource Alternative**

<table>
<thead>
<tr>
<th>NYISO</th>
<th>CAISO</th>
<th>PJM</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% of all calls for 8 hours or less</td>
<td>92% of all calls for 8 hours or less</td>
<td>93% of all calls for 8 hours or less</td>
</tr>
</tbody>
</table>

More than 92% of all calls in three congested markets are for eight hours or less, creating an opportunity for storage to provide peaking capacity.

*Velocity Suite, EPA Continuous Emission Monitoring (CEMS); trailing twelve months on 3/1/2016 for all fossil plants in CAISO, PJM, and NYISO with annual NCF less than or equal to 10%*
As renewable penetration continues to increase, resource flexibility and enhanced capabilities are becoming key for grid operators to manage the grid.

**Opportunity for Renewable Integration**

Storage can enhance electric grids that have a large penetration of renewables by providing both ramping, firming and peaking products.

2) Renew Economy, “California’s duck curve has arrived earlier than expected,” (July 2016); Windpower Engineering, “CEO of California ISO sees 50% renewable energy penetration,” (June 2016)
Storage and solar can deliver more energy at peak price periods and in some cases, capture otherwise lost solar energy due to system design constraints.

### Solar + Storage – DC Coupling & Energy Shifting

**DC Coupling – Boost Solar Farm NCFs**

- **Clipped energy from high DC/AC system**
- **AC injection limit**
- **Additional shoulder production for high DC/AC system**
- **Production from low DC/AC system**

**The Product**

- Wasted clipped energy could be recovered using a DC-coupled battery.

**Shifting Solar output to Peak Hours**

- **Solar to Battery (Charging)**
- **Battery to Grid (Discharging)**

Both of these use cases become increasingly valuable at higher renewable penetration levels, while ITC eligibility improves economics.

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1) This graphic shows an AC coupled battery.
Storage paired with solar is price advantaged due to ITC eligibility, provides incremental capacity value and depending on design can increase solar production

**Solar + Storage: What’s better….AC or DC coupling?**

- Storage can be coupled with solar in two ways: on the AC side of the facility using separate inverters, or on the DC side (i.e. PV panel side) using a DC-DC converter
  - Overall capital and O&M costs will vary based on the selected design
- **DC coupled design captures incremental solar production that would normally be lost due to typical solar facility design of DC oversizing**
  - Energy Arbitrage/shifting and peak firming for capacity are additional benefits
Overall efficiency for a solar + storage system varies with the design and configuration.

**Efficiency Difference Between AC and DC Coupling**

**AC Coupled System**
- Solar PV Array
- Solar Inverters
- Padmount Transformer
- Substation
- GSU Transformer
- Storage Inverter
- Battery

**DC Coupled System**
- Solar PV Array
- Solar Inverter
- Padmount Transformer
- Substation
- DC-DC Converter
- Battery

NEXTera ENERGY
Batteries can be added to solar on the AC or DC side of the inverter, each configuration has benefits and drawbacks.

**AC vs DC Coupled Batteries – 1.75 DC/AC Example**

- **35 Skids x 2.3 MVA = 80.5 MVA**
- **Substation – 85 MVA GSU (Software Limited) to 74.5 MWac**

Diagram:
- **Modules** 1,500 V
  - **355\,W_{dc} \times 5,662\text{ modules} = 2.01\,MW_{dc}**
  - **2.01\,MW_{dc} = 1.75 \times 1.15\,MVA**
- **AC-Coupled Battery**
- **DC-Coupled Battery**

- **Inverter** 1.15 MVA
  - **Pad-mount Transformer** 2.3 MVA
  - **34.5\,kV**
  - **Inverter** 1.15 MVA
  - **POI**

- **80.5\,MVA > 74.5\,MW**
Mitigating solar variability using co-located storage can provide some value on the distribution grid.

**Solar Smoothing via Energy Storage**

Batteries reduce the fluctuation due to cloud cover.
Storage paired with wind can mitigate impacts of off-peak price suppression while firming output during peak hours to provide incremental capacity value.

**Wind + Storage: Price Arbitrage and Firming**

- Storage can allow flexible contractual structures, such as firm peak hour energy deliveries and limiting must-take energy during off-peak.
  - Smoothing intermittent wind output and load following services may provide value, depending on market participation strategy used to offer generation and load, as well as ancillary service participation.

Pairing storage with PTC advantaged, low priced wind energy can provide several use cases that are value add.
Storage connected at the substation and distribution feeder level can increase customer reliability, and provide system level benefits as a load reducer

**Battery Storage as a T&D reliability tool**

- **Distributed Generation (DG) Energy Storage** (i.e. connected at substation or feeder level) can provide a variety of benefits
  - Reduction in customer outages thru islanding/micro-grid applications
  - Localized voltage support, reserves and capacity when aggregated
  - T&D investment deferral

- **DG Energy Storage** is an ideal location for pilot projects due to flexibility and smaller scale

When deployed strategically, battery storage interconnected into the T&D grid can provide both economic and reliability benefits
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The Citrus BESS project is a DC coupled solar + storage facility, providing increased solar facility NCF, while also firming summer peak hour deliveries.

**Project 1: DC Coupled Storage w/ Solar**

- **Overview**
  - Solar facility consists of multiple individual solar inverters rated at 1 MVA each
    - Various DC-DC converter sizes
  - Use Cases: Capture clipped solar production while performing solar shifting and peak firming during summer periods

- **Design / Operational Considerations**
  - Retrofitting a PV inverter to include battery input (software and hardware)
  - Controls required to capture clipped energy w/out impacting solar output
  - Optimization of site design including DC/AC ratios for maximum value
DC Coupled storage is a promising new design approach but requires more complex software controls to optimize performance.

**DC Coupling Example: Clipped Energy Capture**

- Additional solar generation captured will vary based on several design factors
  - DC/AC ratio, solar prediction, battery sizing, etc.
  - Non-clipped energy may be used at times to maximize peak hour deliveries

- Careful consideration of overall site design on the front end will allow maximum value add from storage
The Southwest BESS project incorporates 2nd life EV batteries; system designed to utilize storage in a Peaker / T&D deferral application

**Project 2: DG Storage for Deferral and Ancillary Value**

- **Overview**
  - Capacity: 1.5 MW / Energy: 4 MWh
  - Interconnection: 13kV distribution feeder
  - Use Cases: Peak shaving, frequency response, voltage control, T&D deferral

- **Design / Operational Considerations**
  - Design for both automated and manual control algorithms as a “mini-peaker” via AGC
  - Evaluate costs and complexities of integrating 2nd life batteries vs. new modules
  - Control logic when performing use case “stacking”; ensure proper prioritization
  - Value of T&D deferral vs. avoidance based on expected load growth and other system factors
The Florida Bay BESS project supports a 45 mile radial feeder during outages, as an alternative to a traditional reliability solution.

**Project 3: “Grid Edge” Storage for Outage Support**

**• Overview**
  - Capacity: 1.5 MW / Energy: 1.5 MWh
  - Interconnection: 13kV radial distribution feeder (45 miles)
  - Use Cases: Electrical Islanding (Micro-grid) for outage support, voltage control, short term peaking

**• Design / Operational Considerations**
  - Planning and operating an electrical island with dynamic loads is complex
  - Controls and switching equipment needed to provide seamless transition to and from islanded configuration should be carefully selected
Florida Bay Project: Microgrid Overview
Hurricane Irma made landfall in South Florida in 2017 with sustained wind speeds of 115 mph

Florida Bay Project – Designing for the Storm

• Design Considerations
  – BESS’s platform and battery module building are designed for 180 MPH ultimate wind speed
  – Designed to mitigate the risk of flooding
  – Incorporated anticipated storm surge into design

• Performance during Irma
  – Projects were ready to operate and deliver energy during and after the hurricane

Water reached the fourth step.

No wind borne debris affected the physical plant.
Mobile Battery storage systems can provide premium UPS service to critical loads such as sporting events and manufacturing while also providing utility benefits

**Project 4: Mobile UPS Battery Storage System**

- **Overview**
  - Capacity: 500 kW / Energy: 50 kWh
  - Interconnection: 480V / secondary
  - Use Cases: Reliability (eliminate momentaries and CME), future expansion for longer duration backup under evaluation

- **Design / Operational Considerations**
  - Grid-BESS transfer speeds must meet load requirements (e.g. stadium lighting reliability)
  - Similar transfer speed requirements must be met for critical manufacturing facility loads
  - Long duration expansion to couple premium service with grid benefits can be considered
Storage, located strategically on the grid, can provide summer peaking capacity while improving transmission reliability during N-1 conditions

**Project 5: Storage for Transmission Contingencies**

**Overview**
- Capacity: 10 MW / Energy: 80 MWh
- Interconnection: 13kV distribution substation (two sites)
- Use Cases: Peaking Capacity / Load Reduction, voltage support, and occasional frequency regulation participation

**Design / Operational Considerations**
- Refine overall system design including duration requirements to provide targeted, seasonal transmission load relief
- Local permitting requirements may vary by location
Beyond reliability benefits, DG connected storage paired with solar can provide economic benefits to utility customers when dispatched strategically

**Project 6: DG Solar + Storage for Peak Shaving**

- **Overview**
  - Capacity: 15 MW / Energy: 30 MWh
  - Three projects, each interconnected on a separate 12.47kV load serving feeder
  - Use Cases: solar shifting for targeted peak shaving, voltage and reactive power control

- **Design / Operational Considerations**
  - Interconnection requirements and operational procedures for solar + storage on load serving distribution feeders
  - Customized voltage and backfeed prevention control schemes, dynamic curtailments
Agenda

- Market Overview and Technology Trends
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- Additional Considerations
Energy Storage is a new technology; the pre-existing utility processes and business practices used for day to day operations may need to be refreshed.

## Energy Storage – Integration into Utility Processes

<table>
<thead>
<tr>
<th>System/Stakeholder</th>
<th>Potential Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety/Switching Committees</td>
<td>Switching procedures and clearance processes</td>
</tr>
<tr>
<td>Asset Management Systems</td>
<td>In the System</td>
</tr>
<tr>
<td>SCADA/Communications Team</td>
<td>SCADA points, Remote Access</td>
</tr>
<tr>
<td>Control Center Operations</td>
<td>Control Center screens and Training</td>
</tr>
<tr>
<td>Information Management (IM)</td>
<td>Data bandwidth requirements</td>
</tr>
<tr>
<td>Customer Information System (CIS)</td>
<td>Outage/SAIDI tracking for microgrid applications</td>
</tr>
<tr>
<td>Trouble Call Management System</td>
<td>Alarm Response Guidelines for field technicians</td>
</tr>
<tr>
<td>Environmental</td>
<td>Environmental review and policies for battery disposal</td>
</tr>
</tbody>
</table>

Significant back office effort may be needed to define how battery storage systems are integrated into utility business and operational processes.
Battery storage capacity (MWh) has to be sized to account for DC and AC losses to meet the delivery requirement at the Point of Interconnect.

Designing for Round Trip Losses

Sizing Battery Capacity to deliver constant AC Power for a defined duration requires grossing up for all losses

Round Trip Losses:
- Battery (5.0%)
- Aux Load (1.0%)
- Inverter (4.0%)
- Transformer (1.0%)
- Cable (0.5%)

Total ~11-12%

(1) Shown for Li-ion batteries. Round trip losses vary by technology.
Application versatility, declining capital costs and low maintenance costs have made lithium-ion the front runner vs other battery technologies

**Battery Technologies – Pros and Cons**

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Dominant Companies</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium Ion</td>
<td>LG Chem, Saft, Tesla, Samsun, Lishen</td>
<td>Synergies with EV, Strong balance sheets to support equipment warranties, R&amp;D budgets</td>
<td>Versatile product up to 4-6 hrs but potential degradation at low or high State of Charge idle periods</td>
</tr>
<tr>
<td>Lead Acid</td>
<td>Johnson Controls, Exide, EaglePicher, East Penn</td>
<td>Low cost</td>
<td>Cycle life, Energy density, restricted state of charge operation</td>
</tr>
<tr>
<td>Sodium Based</td>
<td>NGK, GE Energy Storage, Fiamm, Sumitomo, Primus Power, Imergy, ZBB</td>
<td>Good over long duration (NGK’s sodium sulphur commercial at 8 hours)</td>
<td>High temperature operation results in high aux load, safety risk</td>
</tr>
<tr>
<td>Flow Batteries</td>
<td>Sumitomo, Primum Power, Imergy, ZBB</td>
<td>Cost effective in long duration applications</td>
<td>Lifetime costs, round trip efficiency, leaks, component failure mode risk</td>
</tr>
<tr>
<td>Thermal Storage</td>
<td>Ice Energy, Calemac</td>
<td>Half the price of lithium ion for 4hr durations; no degradation</td>
<td>Compressor replacements required within 20-year life</td>
</tr>
</tbody>
</table>
Battery Degradation Validation

- Battery’s life span is impacted by various factors (full or partial cycling, resting state-of-charge, internal temperature, etc.)
  - Battery degradation is a key risk factor in long term battery storage applications
- NextEra commissioned a new battery test facility in 2014 to build institutional knowledge around battery design and degradation characteristics
  - Experiment with varying duty cycles, state of charge, and temperatures
  - Predictive modeling of battery degradation curves, end of life, and long term O&M costs
  - Validate manufacturer stated performance characteristics

Battery application and use-cases will effect the long term degradation of the system and must be considered
Which of the two use cases below will result in higher battery degradation (i.e. lower capacity) over 10 years?

**Battery Storage Degradation – Pop Quiz**

**Option A**

**Option B**
Predicting long term degradation accurately can be challenging, as there are a variety of factors that all impact the battery life cycle.

**Battery Storage Degradation – Pop Quiz Results**

**Option A**

![Graph showing remaining capacity over 10 years with 81% remaining capacity after 10 years]

**Option B**

![Graph showing remaining capacity over 10 years with 78% remaining capacity after 10 years]
Batteries degrade over time and need to be replenished over the life of a project in order to maintain the same level of MWh energy output at POI

Select Factors Impacting Battery Degradation

<table>
<thead>
<tr>
<th>Number of Cycles</th>
<th>Number of times the battery is charged and discharged (e.g. 255 annual cycles = 1 full cycle per day on all non-holiday weekdays)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of Discharge</td>
<td>How deep is the battery charged and discharged between 0% and 100%</td>
</tr>
<tr>
<td>Idle Time &amp; Rest SOC</td>
<td>How often is the battery idle; battery also degrades in idle state (also known as “calendar degradation”); resting SOC when idle is a key driver in degradation</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Different combinations of anode, cathode and electrolyte material have varying degradation profiles</td>
</tr>
</tbody>
</table>

Validation battery degradation profiles provided by OEMs via independent testing can provide more certainty in asset life
Not all lithium-ion batteries are created equal; the specific chemistry selected for each project should be dependent on the intended use cases.

**Battery Chemistry**

1) Bloomberg New Energy Finance - Lithium-Ion Battery Materials Supply and Demand
2) LMO – Lithium Manganese Oxide, LFP – Lithium Iron Phosphate, NMC – Nickel Manganese Cobalt, NCA – Nickel Cobalt Aluminum, LCO – Lithium Cobalt Oxide
3) Implied Cycle Life from Apple IPhone Warranty
4) Tesla Model S Limited Warranty; Tesla’s Model S can swap only the battery pack for performance upgrades

**Battery Life**

- **Typical consumer electronic battery life is ~4 years**
  - Typically select the highest density battery without significant regard for cost

- **Typical electric vehicle battery life is 8 years**
  - EV battery has a long single charge range

- **Typical stationary battery storage life is 7-15 years**
  - Lifespan is highly dependent on thermal management and cycling
  - Continual refurbishment to extend lifespan to 25 years is possible with proper initial design of power electronics

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1) Bloomberg New Energy Finance - Lithium-Ion Battery Materials Supply and Demand
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**Active Material Inside Lithium-Ion Cells**

- Oxygen
- Phosphorus
- Iron
- Aluminum
- Cobalt
- Nickel
- Manganese
- Lithium
- Phosphorus (Electrolyte)
- Graphite
- Recyclable

**Least Expensive**

**Most Expensive**

<table>
<thead>
<tr>
<th>Active Material</th>
<th>LMO</th>
<th>LFP</th>
<th>NMC</th>
<th>NCA</th>
<th>LCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMO</td>
<td>26%</td>
<td>27%</td>
<td>22%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>LFP</td>
<td>45%</td>
<td>13%</td>
<td>13%</td>
<td>30%</td>
<td>38%</td>
</tr>
<tr>
<td>NMC</td>
<td>3%</td>
<td>24%</td>
<td>12%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>NCA</td>
<td>29%</td>
<td>29%</td>
<td>33%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>LCO</td>
<td>22%</td>
<td>29%</td>
<td>33%</td>
<td>33%</td>
<td>32%</td>
</tr>
</tbody>
</table>
There are several important factors that need to be considered in designing the battery system for safety

**Important Considerations in Battery Safety**

**Battery Chemistry**
Select battery chemistry based on use case

**Battery Management System**
Battery Management System monitors the battery’s state of health (voltage, current, temperature)

**Battery Cooling**
HVAC system needs to be properly designed and sized to provide optimal cooling to batteries and to avoid excessive battery heating

**Fire Suppression System**
Fire suppression agent should be carefully selected for given battery chemistry

**Local Fire Department**
Local fire department should be made aware of the battery chemistry and response protocols

Safety must be a top priority in design, construction and operation of a battery system
Energy Storage is not a net generation resource; as a result, power purchase pricing is often stated in $/kW-month rather than in $/MWh

**Contracting Mechanisms for Energy Storage**

- **Pricing based on storage nameplate rating (in kW)**
  - Longer duration systems will have a higher $/kw-month rate
  - Contract terms may include guarantees on storage capacity/duration, or alternatively may cap the annual degradation

- **Storage is not a net generator, as it withdraws more energy from the grid (or from co-located renewables) than it discharges**

Energy Storage pricing methodology is in some ways similar to a Fossil Peaker – payment for the ability to use when desired.