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Today’s Speakers:

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www.energystorage.org
Mission Statement
YPE aims to facilitate the advancement of young professionals in the energy industry around the world through social, educational and civic service oriented events. The desired outcome of YPE is to foster an environment where members can learn from each other’s experiences, share industry knowledge and discuss career matters.

Vision Statement
YPE is a positive catalytic force in uniting the young energy leaders of today. YPE prepares its members to be the best leaders for their communities and for the global energy industry.
Energy Storage 101
Applications, Markets, Technology and Policy

Caleb Waugh, Head of Analytics – Energy Storage
Lockheed Martin Energy

www.energystorage.org
Caleb Waugh leads energy storage business analytics at Lockheed Martin Energy applying advanced analytics to guide business development, strategy and product design. He is the chief architect of Lockheed’s high-fidelity techno-economic models used to evaluate business cases for *Lockheed’s GridStar™ Lithium and Flow* energy storage solutions in wholesale, utility, microgrid and distributed applications.

Caleb holds dual graduate degrees from the Massachusetts Institute of Technology in Nuclear Physics and Technology and Policy and has published and presented in many leading journals and conferences.
Introduction

• While most fuel-based energy commodities, such as oil or natural gas, are easy to store and used only when needed, given the lack to date of cost-effective and scalable storage solutions, almost all electricity on the grid is produced and consumed in real-time.

• Electricity markets are the only market in the world where the supply and demand of a good must be met instantaneously and at all times.

• Today, energy storage constitutes only 3% of the world’s electricity capacity and the lack of cost-effective, reliable and scalable storage options has resulted in today’s electricity grids and power lines being sized to meet peak instead of average demand.
History of Grid-connected Storage (1/2)

- While limited, energy storage on the grid is not new. Most existing capacity is pumped-hydro that was built out largely to pair with nuclear generation.
- The U.S. has over 20 GW or 2% of total grid capacity as pumped hydro. 95% of installed storage capacity in the world is pumped hydro.

Bath County – 3.003 GW
Ludington – 1.872 GW
Castaic – 1.566 GW
Raccoon Mountain – 1.652 GW
History of Grid-connected Storage (2/2)

- Current developments in grid-connected storage are more focused on **electrochemical battery storage** leveraging advancements and battery technologies for electric vehicles.
- The U.S. recently surpassed 1 GWh of installed battery storage capacity.
Applications

- Energy storage can be used for applications across the electricity value chain from generation, transmission, distribution and all the way to the end user.
- Application requirements vary by power (kW) and energy capacity (kWh)

KEY ENERGY STORAGE APPLICATIONS

Electricity Supply
- Electric Energy Price Arbitrage
- Electric Supply Capacity

Ancillary Services
- Frequency Regulation
- Load Following
- Reserve Capacity – Spinning/Primary
- Voltage/VAR Support

Grid Systems
- T&D Upgrade Deferral
- T&D Congestion Relief
- Substation On-site Power

Microgrids
- Islanded Microgrids

End User/ Customer
- Demand Charge Management
- Transmission Charge Management
- Capacity Charge Management (ICAP)
- Energy Charge Management
- Demand Response
- Electric Service Reliability
- Electric Service Power Quality

Renewables
- Solar Energy Time-shifting
- Wind Energy Time-shifting
- Solar Smoothing/Firming
- Wind Smoothing/Firming

Energy storage can be used for applications across the electricity value chain from generation, transmission, distribution and all the way to the end user. Application requirements vary by power (kW) and energy capacity (kWh).
Markets

- Markets and market applications are commonly differentiated as being either: 1) in-front of the meter (FTM) or behind-the-meter (BTM)
  - **Front of the meter:** energy storage interconnected on distribution or transmission networks or in connection with a generation asset. Applications are largely driven by ISO/RTO market products (e.g. electricity, ancillary services) or network load relief
  - **Behind the meter:** energy storage interconnected behind a commercial, industrial or residential customers utility meter primarily providing bill savings (e.g. demand charge management)
- As grids become increasingly distributed the line between FTM and BTM becomes blurred where storage is seen as providing value *across the meter*.
- **Energy storage project value is highly market dependent.** Biggest markets currently in the U.S. are California and the PJM ISO. Massachusetts and New York are starting to open in a big way as well. Other markets will continue to open up as participation rules evolve and energy storage costs continue to come down.
Energy Storage Technologies

• Wide variety: electrochemical (e.g. li-ion, redox flow, etc.), mechanical (e.g. pumped hydro, compressed air, flywheels, etc.), thermal (e.g. ice batteries, water heaters, etc.)…

• Historically dominated by pumped hydro and most new capacity in the U.S. is lithium ion

• Technology Considerations
  • Project Lifetime – Lifetime of the project compared to usable lifetime of battery technology
  • Duty Cycles – The number of annual full charges/discharges. Can impact degradation.
  • Depth of Discharge – Depth the battery is discharged. Affects usable capacity and degradation
  • Average Rest State of Charge – Average charge of the system while not in use. Affects availability and degradation
  • Safety – Fire, toxicity, environmental or other risk factors
  • Technology Maturity – Lots of innovation into new batteries. Is the technology mature enough for deployment at scale?

• Hard to compare between technologies due to variation across all considerations. Benchmarking is best done using Total Cost of Ownership (TCO) comparisons
Software, Aggregation and “Value Stacking”

- Where the sun is what rises and gives value to PV solar, software is the “sun” that rises and sets on energy storage

- Major software components include:
  - **Systems Integration**: low-level software that integrates all components around the battery (e.g. power conversion, thermal management, etc.)
  - **Economic Dispatch**: software that determines when to charge and discharge the system to gain the maximum economic benefit for the intended applications. Enables system to “value stack” across multiple revenue/savings streams
  - **Fleet Aggregation**: manages fleets of smaller distributed energy storage systems and can deploy it as if a single larger system
  - **Business Application Analytics**: techno-economic-financial modeling tools to determine the value proposition and performance of an energy storage project.
Policy

Federal

• Tax Incentives – Storage can qualify for the investment tax credit (ITC) and production tax credit (PTC) when paired with solar or wind. Industry is advocating for a stand alone storage ITC.

• Market Participation – On February 15th, 2018 the U.S. Federal Energy Regulatory Commission (FERC) issued a landmark order (Order 841) mandating that Regional Transmission Organizations (RTO’s) and Independent System Operators (ISO’s) adopt new participation models for energy storage that require storage be able to participate in all markets and services for which it is technically capable regardless of location.

State

• Procurement Mandates: California AB-2514 (1.3 GW), Massachusetts (200 MWh), New York (proposed 1.5 GW)

• Incentive Programs: California Self Generation Incentive Program (SGIP), Solar Massachusetts Renewable Target (SMART)
Recent Developments in Energy Storage

Marissa Gillett
Vice President, External Relations
Energy Storage Association

April 4, 2018
About the Energy Storage Association

ESA’s mission is to accelerate the widespread use of competitive and reliable energy storage systems in North America. To achieve this mission, ESA educates stakeholders, advocates for public policies, accelerates market growth, and delivers direct member value.

- Established 28 years ago
- Diverse membership—vendors, developers, independent generators, utilities & other power sector stakeholders
- Federal, regional, & state policy engagement
# About the ESA

The ESA (Energy Storage Association) represents a variety of entities involved in the energy storage sector. These include:

- **ESCO**
- **IPP**
- **Electric Utilities**
- **Financiers**
- **Developers**
- **Installers**
- **Manufacturers**
- **Component Suppliers**
- **Integrators**
- **Legal Entities**
- **Insurers**
- **System Support**
FERC Order 841

- RTOs/ISOs must file a tariff amendments that establish a “participation model” for electric storage
  - Will also include changes to business practice manuals and software
- 5 sections of the Order
  - Storage is eligible to provide all capacity, energy, and ancillary services that the resource is technically capable of providing
  - RTOs/ISOs account for the physical and operational characteristics of electric storage resources through bidding parameters or other means
  - RTO/ISO minimum size requirements do not exceed 100 kW
  - Storage can be dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer
  - Storage will pay wholesale LMP for charging energy
The Good, the Bad, & the TBD

• The Good
  • Establishes a participation model that recognizes the physical and operational characteristics of storage resources
  • Opens up all market products
  • Provides clarity around market access – tariffs will be explicit
  • Improves dispatch flexibility and price formation
  • Improves market access for distributed resources
  • Ensures charging energy will be priced appropriately

• The Bad
  • Large amount of flexibility given to ISOs on many points, allows changes that do not help storage
  • Does not modify performance requirements for Capacity
  • Some market design elements remain stuck in traditional generator model
  • Does not address some distributed storage resource issues
  • Can increase cost of charging energy

• The TBD
  • Participation model design
  • Whether and how to use bid parameters to model operational characteristics
  • Energy accounting and metering
Order 841 timeline & uncertainty

- RTO/ISO compliance filings due to FERC Dec 1, 2018
- RTO/ISO implementation deadline Dec 1, 2019
- Motions for rehearing may change this
  - Numerous parties claim FERC preempts state authority over whether and how distribution-connected resources may participate in wholesale markets
  - Other parties request more time for implementation
  - California parties seeking to avoid backwards movement (e.g., transmission charges)
Removing barriers in wholesale markets

Modernize tariff, operating, and planning structures appropriately to reflect the capabilities of advanced technologies → batteries will compete on its own merits

• Market access (generator services & Tx services)
  • FERC Order 841
• Physical access (interconnection)
  • FERC RM17-8
• Multiple-use enabled (Tx/Gen & wholesale/retail)
  • FERC PL17-2; California PUC D.18-01-003
• Price signals for flexibility (fast response/ramp, etc)
  • Order 755; Order 825
• Equitably accommodated
  • Order 842
• Included in transmission planning processes
Removing barriers in state markets

Capture the full VALUE of energy storage
Ensure accurate market signals that monetize economic value, operational efficiency, and societal benefits

Enable COMPETITION in all grid planning and procurements
Storage can be a cost-saving and higher-performing resource at the meter, distribution, and transmission levels

Ensure fair and equal ACCESS for storage to the grid and markets
Reduce market and grid barriers that limit the ability for energy storage systems to interconnect
State policy moving storage forward

State policy actions in 2017

- Regulatory Action
- Legislative Action
- Regulatory and Legislative Action
Battery Storage in Utility IRPs

Find ESA’s Primer on Storage in IRPs at:
http://energystorage.org/IRP
Other Recent Developments

• March 2018

• IRS Private Letter Ruling on Residential Retrofit Storage+Solar

• Massachusetts Governor Announces Clean Peak Standard Legislation

• 2018 Federal Omnibus – Increased Support for Energy Storage
Other Recent Developments

• April 3, 2018 U.S. Section 301 Tariff Announcement

“The Energy Storage Association (ESA) anticipates that the inclusion of Chinese battery components in the tariffs, as drafted, will likely represent a negligible impact on the growth of the energy storage market. Nonetheless, ESA is concerned by the battery tariffs announced yesterday because the Administration is creating unnecessary uncertainty for the U.S. energy storage market,” said Kelly Speakes-Backman, CEO of ESA. “If these tariffs are adopted, the companies and people who plan, build, and service battery storage facilities will be faced with risk that may inhibit storage deployment, even as the U.S. looks to strengthen its energy infrastructure and enhance resilience.”
Energy storage is Proven, Ready for Business.

Join the drive to 35 GW by 2025.

Keynotes include
MA Governor Charlie Baker
DOE Asst. Secretary Bruce Walker
NYP A CEO Gil Quiniones
Fluence CEO Stephen Coughlin
MA DOER Commissioner Judith Judson
Questions can be submitted through the chat box in your browser.
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Change of contact information? New employees?

Let us know!

Contact **Richie O’Neill**, Membership Manager
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April 18–20, 2018
Boston, MA

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Thank you

Please submit ideas for future webinars to Sonora Munks at s.munks@energystorage.org