Renewable Energy Roundtable Discussion

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Renewable Energy Storage Systems

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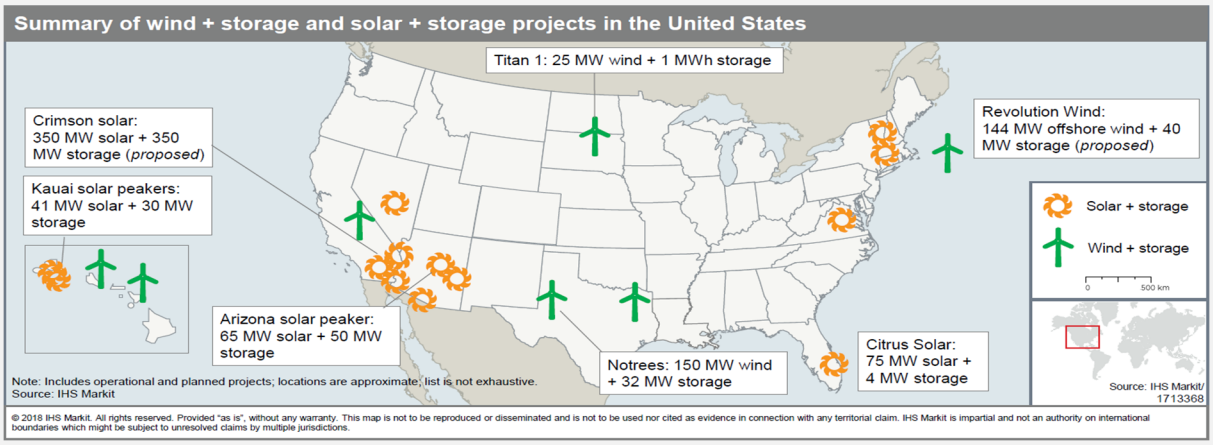
Battery Energy Storage Systems (BESS)

US states taking the lead by proposing and adding new legislation



- Hawaii – two projects at $0.08/KWh
- Massachusetts – 1,000 MWh by 2025
- New York – 1,500 MW by 2025
- California – 1,325 MW by 2024
- Oregon – 5 MWh by 2020
- New Jersey – 2,000 MW by 2030
- Arizona – 3,000 MW by 2030

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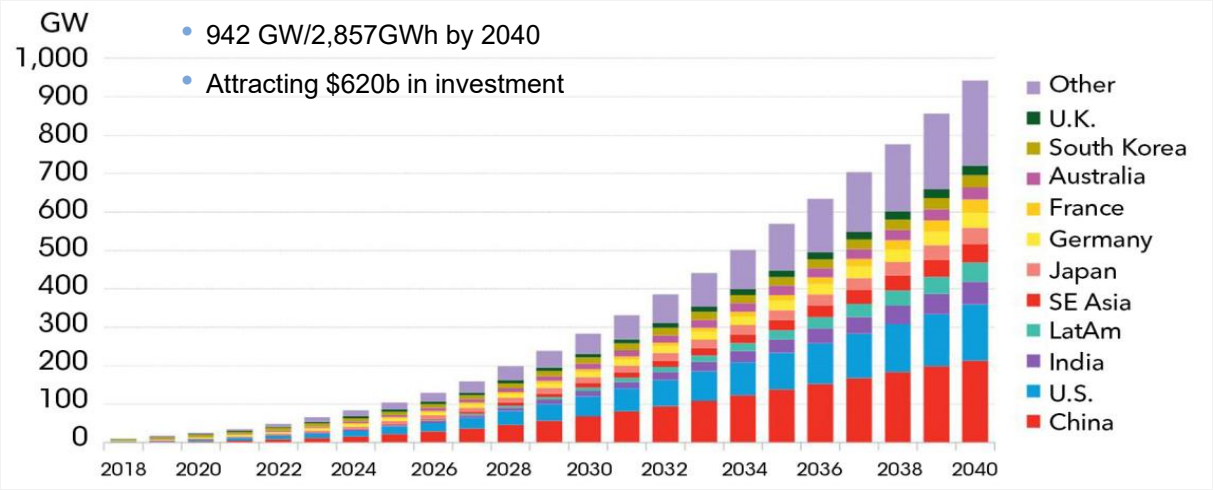
BESS Leading Nations (Bloomberg)

Global cumulative storage deployments



- 942 GW/2,857GWh by 2040
- Attracting $620b in investment

Source: BloombergNEF

Leading Companies

SIEMENS
A123 SYSTEMS
LG Chem
ABB
BOSCH
saft
SAMSUNG SDI
BYD
AXION POWER
ALSTOM
AES
SOLARGRID storage

https://themarketfact.com/2019/06/06/global-battery-energy-storage-systems-for-smart-grid-market-2019/

Current Projects

- Lawa'i Solar and Energy Storage Project
- $0.11/kWh compared to fossil fuel-generated $0.16/kWh
- Five-hour duration
- Currently world's largest solar generation plus storage project in the world
- 100 MWh lithium battery energy storage

bigislandnow.com/2019/06/05/sen-hirono-hawaii-on-leading-edge-of-incorporating-renewable-power-energy-storage/

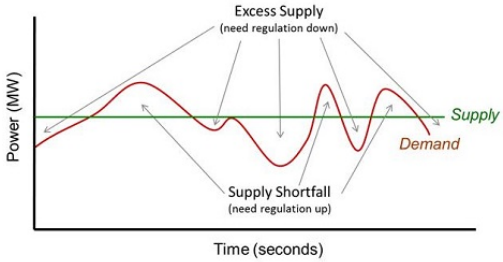
- World's largest virtual battery plant
- Abu Dhabi
- Ten locations / 15 systems
- 108 MW / 648 MWh
- Six-hour duration
- Sodium sulfur battery energy storage

https://www.energy-storage.news/news/uae-integrates-648mwh-of-sodium-sulfur-batteries-in-one-swoop

Ancillary Services

Frequency regulation

- Rapid response time and ability to charge and discharge efficiently
- Reduce amount and cost of reserves needed to provide services to the grid
- Decrease issues between generation and load



Source: E&I Consulting

Figure 4. Frequency regulation needs due to momentary differences between demand and a nearly constant supply.

https://alcse.org/battery-storage-ancillary-services/
http://energystorage.org/energy-storage/energy-storage-benefits/benefit-categories/grid-operations-benefits

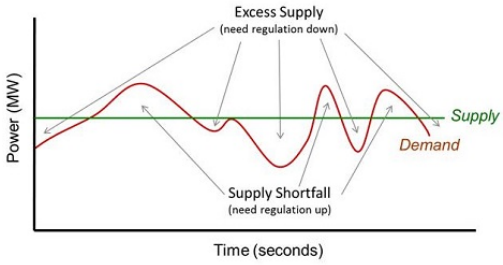
Ancillary Services

Baseload

- Fuel cells 24/7, but batteries discharge during peak times

Competition

- Battery energy storage systems are beginning to compete with peaking plants (natural gas / coal) and will only get more competitive
  - Hawaii gets 40% of evening peak power demand from Lawa'i facility
  - Providing lower $/kWh



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Challenges with BESS

https://www.powermag.com/practical-considerations-siting-utility-scale-battery-projects/

Challenges with BESS

- Less than 5% of lithium-ion batteries are recycled due to cost
  - Landfills
  - Repurposing
- Improper disposal can lead to contamination of the soil and water
- Energy storage systems typically last 10-15 years due to battery degradation
  - Degradation
    - Battery operating temperature
    - Experienced currents
    - State of charge experienced
    - Interval of state of charge most experienced by battery

https://www.utilitydive.com/news/how-can-the-us-reduce-battery-costs-and-foreign-dependence-recycle-argonn/556238/
https://www.energy-storage.news/blogs/easing-the-risks-of-battery-investment-1

https://electrek.co/2019/06/01/tesla-fire-supercharger/

https://q13fox.com/2017/01/23/samsung-blames-batteries-for-galaxy-note-7-fires-2/

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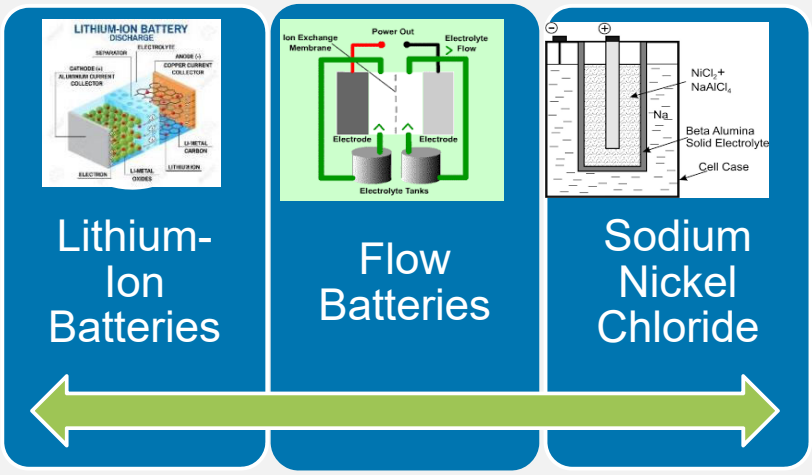
Technology

- Front of meter
- Behind the meter
- Battery types differ across projects



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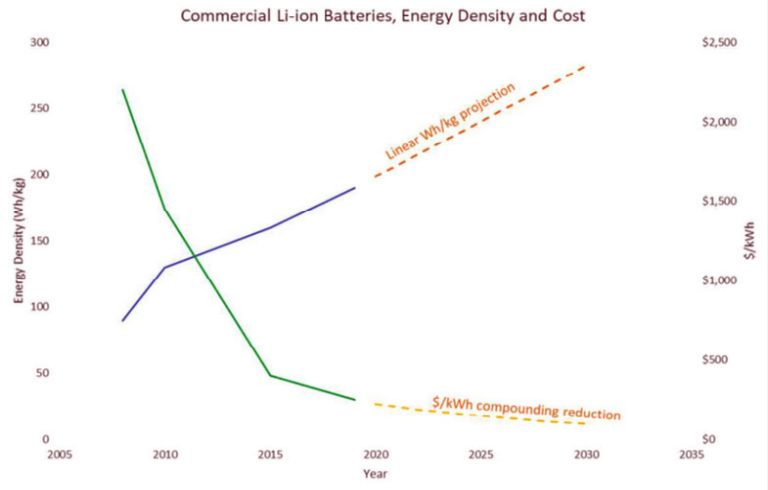
Technology

	Max power rating (MW)	Discharge time	*Max cycles* or lifetime	Energy density (watt-hour per liter)	Efficiency
Pumped hydro	3,000	4h – 16h	30 – 60 years	0.2 – 2	70 – 85%
Compressed air	1,000	2h – 30h	20 – 40 years	2 – 6	40 – 70%
Molten salt (thermal)	150	hours	30 years	70 – 210	80 – 90%
Li-ion battery	100	1 min – 8h	*1,000 – 10,000*	200 – 400	85 – 95%
Lead-acid battery	100	1 min – 8h	6 – 40 years	50 – 80	80 – 90%
Flow battery	100	hours	*12,000 – 14,000*	20 – 70	60 – 85%
Hydrogen	100	mins – week	5 – 30 years	600 (at 200bar)	25 – 45%
Flywheel	20	secs - mins	*20,000 – 100,000*	20 – 80	70 – 95%

Characteristics of selected energy storage systems (source: The World Energy Council)

Price Trends

- Utility-scale lithium-ion battery storage system dropping 52% between 2018 and 2030

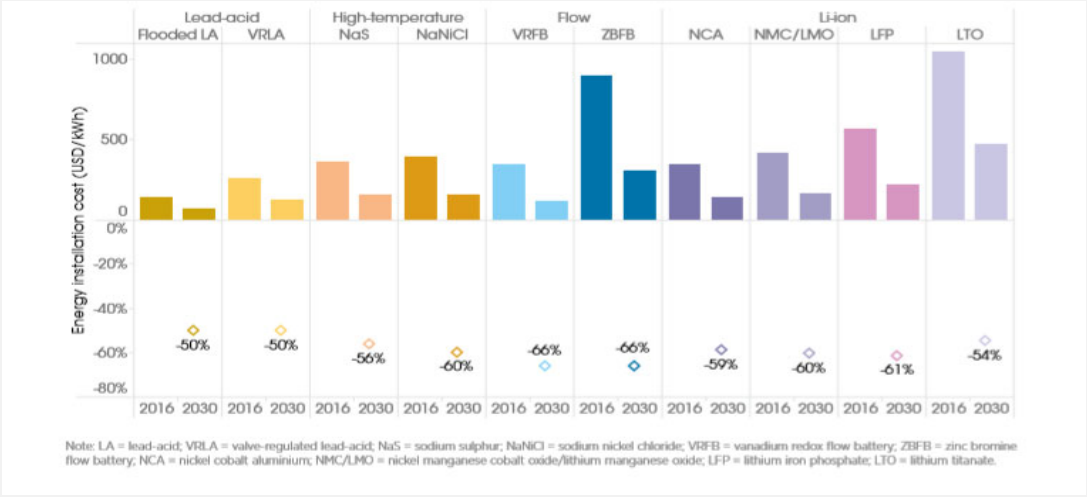


https://www.energy-storage.news/blogs/easing-the-risks-of-battery-investment1

https://about.bnef.com/blog/energy-storage-620-billion-investment-opportunity-2040/

Project Cost Comparison

Battery electricity storage system installed energy cost reduction potential, 2016-2030



https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017_Summary.pdf?la=en&hash=2FDC4493992OF8D2BA29CB762C607BC9E882D4E9

Renewable Underwriting

Patrick Stumbras

President & Managing Director

PERse

Critical Factors

- Traditional natural catastrophe (NAT CAT) exposures (named windstorm / earthquake / flood) along with hail, wildfire, and tornadoes
- Warranty in place (or long-term service agreement / full service agreement and scope of agreement – full parts / labor, scheduled and unscheduled maintenance)
- Who is doing operations and maintenance? Self performance?
- New acquisitions – unknown loss history as part of larger corporate programs with high retentions? were there losses paid under warranty that became exposed post-warranty?
- Technology
  - New, larger onshore wind turbines (4 MW+) with unknown or limited operational history
  - Battery storage
- Manufacturer issues, i.e. carbon fiber blades, gearboxes, lightning protection

Data Required / Key Differentiators

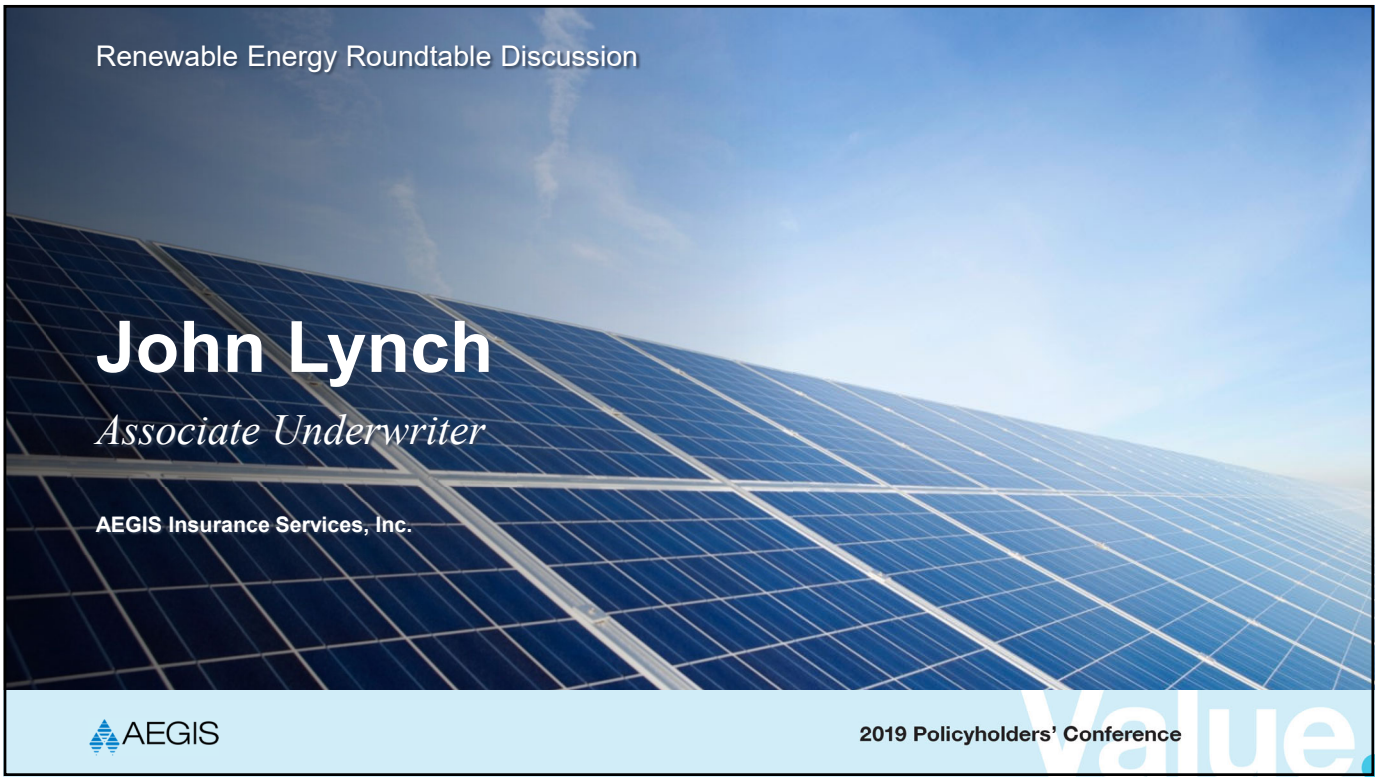
- Latitude and longitude (per turbine where possible)
- Complete application
- Contracts
  - Turbine supply agreement (TSA)
  - Power purchase agreement (PPA)
  - Engineering, procurement and construction (EPC) / balance of plant (BOP)
- Spare equipment
- Replacement time / sourcing for critical equipment, especially newer technology
- Underlying contractor liability limits
- RMS modelling (PERse in-house)

Claims Trends

- Replacement cost exceeds values on statement of value (SOV): re-permitting, decommissioning / recommissioning, environmental
- Lightning protection failure
- More turbine fires
- Transmission & Distribution icing, wildfires
- Tornadic and hail activity
- Microfractures

State of Current Market

- Decreased overall capacity in the marketplace
- Poor loss ratios
- London restrictions on growth / capacity, business plans thoroughly scrutinized
- Increases in rate / tightening of terms
- Markets leaving the renewable space
- Offshore coming quickly
- Increase in repowering / aging fleet
- State mandates are very aggressive
- Last two years have been worst back-to-back NAT CAT losses for the insurance marketplace (est. $700 billion) – this year will be critical



Renewable Energy

- AEGIS members in the renewable sector
- Capacity – $400 million AEGIS
  - Up to $1 billion in limits from the PERse alliance

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Value

Renewable Energy

- The AEGIS & PERse alliance allows members to maintain their relationship with AEGIS while they expand into the renewable sector
  - PERse offers underwriting expertise as well as engineering experience
  - AEGIS members will be able to expand their annual property credit

Renewable Energy

- AEGIS membership & new opportunity
  - Members expanding & changing their portfolio of assets can use AEGIS for competitive renewable coverage
  - PERse's relationships expand past the AEGIS membership, which allows the mutual to grow market knowledge at a steady pace
  - Renewable energy initiative − a long-term commitment to a growing area for members
  - AEGIS supports members as they grow in the renewables area
  - Opportunity to expand via non-members with renewable coverage

Introduction

- EEI's primary motion CAM 855-1, was successful in securing a scope-level exclusion for utilities under NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems (ESS)*, based on compliance with IEEE C2
- Any changes to IEEE C2 to address NFPA 855 concerns will not be in place until 2022
- As IEEE C2 currently does not cover ESS installations there is the potential for authorities having jurisdiction to apply NFPA 855 to utility installations until IEEE C2 is adopted with the ESS requirements
- This presentation provides general guidelines for the construction of, and fire protection for, grid energy storage facilities and supporting equipment and for the lithium-ion battery energy storage system

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The Exposure

- The fire risk involving lithium-ion battery energy storage systems has been adequately demonstrated thru laboratory testing and by fires at operational sites, and needs to be addressed to minimize the hazard and financial loss
- The Exponet, Inc. report, ***Development of Sprinkler Protection Guidance for Lithium-Ion Based Energy Storage Systems***, published in June, 2019, demonstrates this fire risk and provides sprinkler protection guidelines – pictures and recommendations are included here
- Both LFP (lithium iron phosphate) and MNC (manganese cobalt oxide) were tested. Further testing is needed for specific configurations including height, clearance and rack separation

Testing Results

Large-scale free burn
of LFP batteries after 71 minutes

Large-scale free burn
of MNC batteries after 89 minutes

Construction

- Provide minimum two-hour fire rated construction for any floors and one-hour fire rated construction for the roof and exterior walls. Provide a minimum one-hour fire rated wall on floors between the battery storage areas and support areas
- Fire separation is needed for each 50 MWh of batteries in a commercial building, unless successful full scale fire tests are provided
- Provide adequate separation or exposure fire protection between the building and exposing structures and support facilities, such as cooling towers and transformers
- Combustible construction must not be utilized
- Below-grade areas should not be used for battery rooms

Fire Protection

- The building should be provided with a UL-listed central station or owner monitored fire alarm system covering the fire protection systems in accordance with NFPA 72. The system should include, but not be limited to, water supplies and fire pumps, sprinkler systems, special extinguishing systems, and fire and gas detection systems
- Provide automatic sprinkler protection within the battery rooms designed to a 0.3 gpm/ft^2 (12 mm/min) over 2500 ft^2 (230 m^2) using ½ inch, 165ºF rated heads
- Provide automatic sprinkler protection within all offices, storage and locker rooms and non-electrical service areas designed to an Ordinary Hazard Group II design using ½ inch, 165ºF rated heads
- Provide gaseous extinguishing system protection for all critical BMS (Battery Management System) areas and control rooms

Fire Protection

- Provide a reliable water supply to the fire protection systems for the project − a reliable water supply is defined as a single connection to a gridded municipal water system fed by multiple pumps and tanks
- If the project is located in a remote area, the water supply can consist of a single diesel engine-driven fire pump and an above ground water tank
- Provide approved noncombustible cooling towers for the building. An option in water restricted areas would be a closed loop, above ground, air cooled condenser system
- Protection for indoor or outdoor transformers should be in accordance with NFPA 850 *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations* Chapter 5.1.4 and 5.1.5

Fire Alarms, Ventilation, Gas Detection

- Building systems such as intrusion, HVAC, emergency exhaust and emergency power systems should be remotely monitored
- As determined by the business risk analysis study, subdivide HVAC system to minimize the exposure of smoke and heat from being circulated into multiple areas; design the HVAC system to exhaust the zone of the alarm condition, while pressurizing the adjacent zones
- Rooms containing battery systems should be protected by a gas detection system, which shall be designed to activate where the level of flammable gas exceeds 25% of the lower flammable limit (LFL), or where the level of toxic or highly toxic gas exceeds half the level immediately dangerous to life or health; ventilation systems should be arranged to go to full exhaust on detection of flammable gases exceeding threshold limits


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