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8 December 2022

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**Marija Maisch**

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# How to protect BESS to increase reliability and maximize return on investments




**Immanuel Umenei**

Senior Global Segment Manager, Renewable Energy  
**Littelfuse, Inc.**

# Welcome!

Do you have any questions? ? 

Send them in via the Q&A tab.  We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 

We'll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience.  



# How to Protect Energy Storage Systems for Reliability & Maximum Return on Investments



Expertise Applied | Answers Delivered

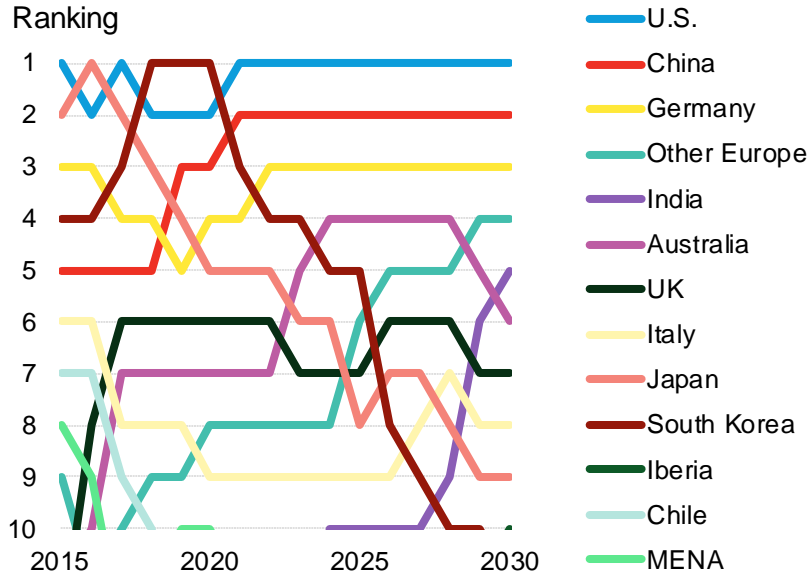
# Littelfuse

## Empowering a Sustainable, Connected, and Safer World

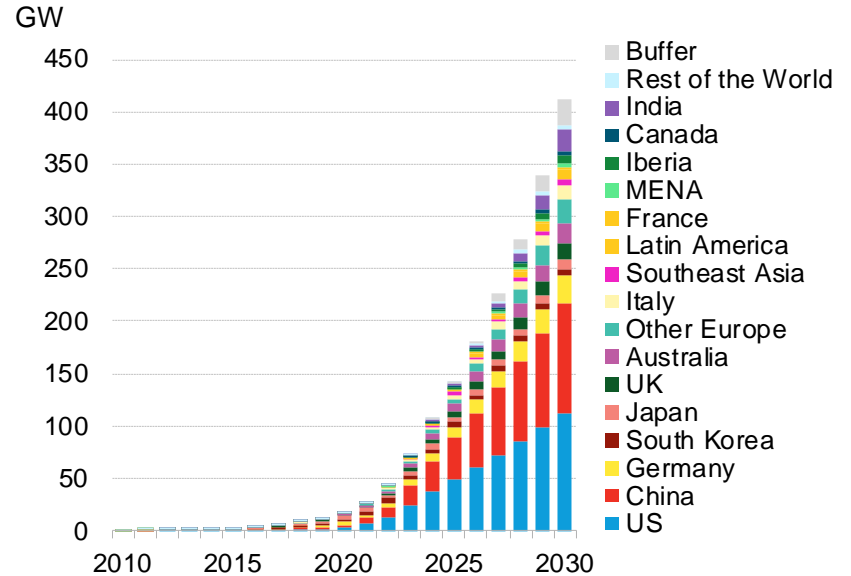


# Country Ranking for Energy Storage Capacity

## Region ranking based on cumulative storage capacity by power output

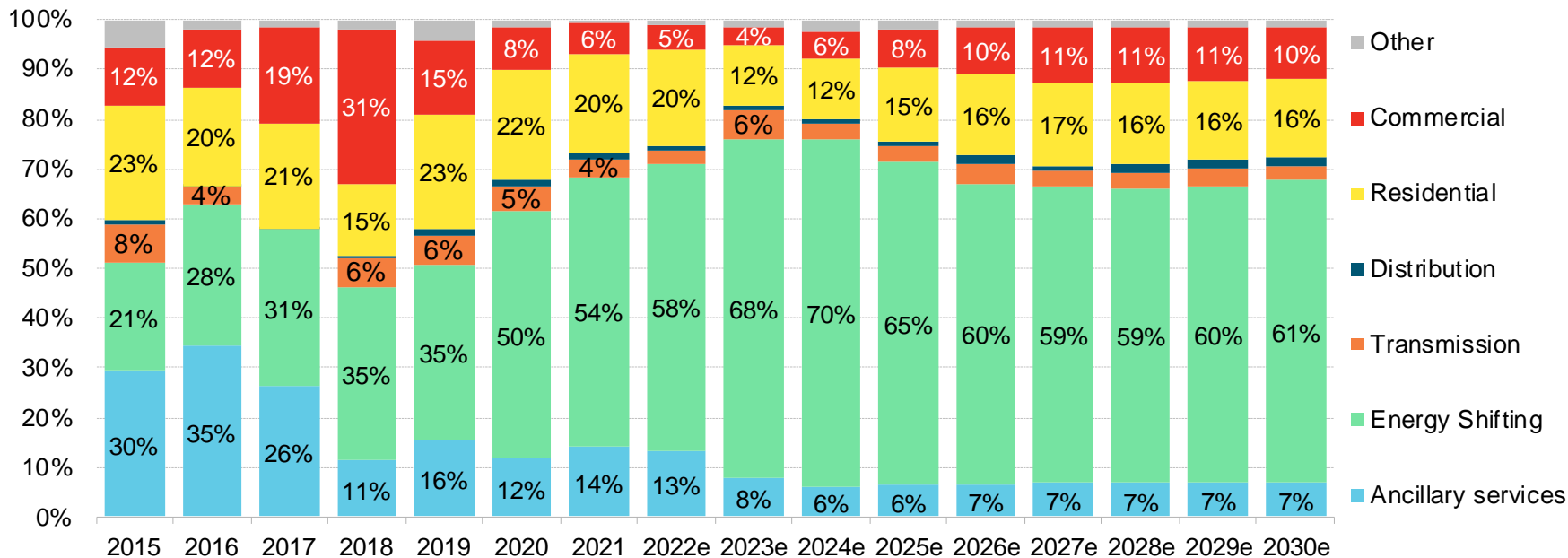


## Global gross cumulative capacity by power output and key markets



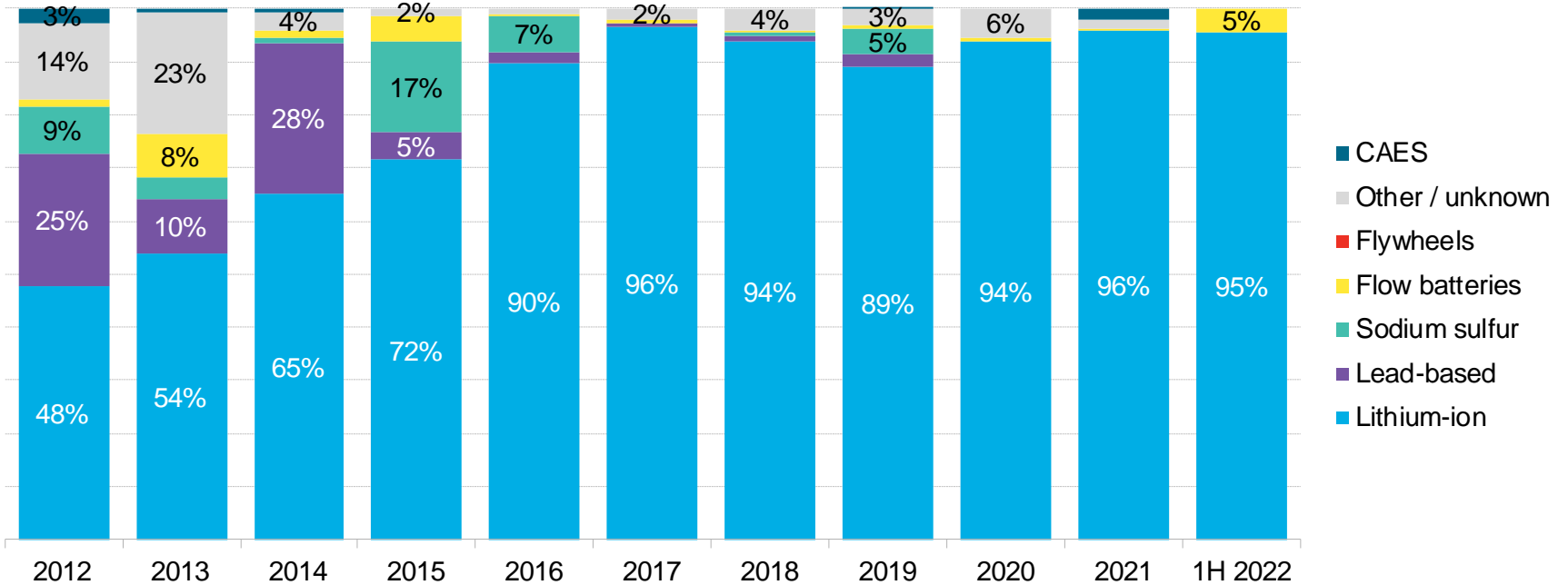
Source: BloombergNEF Note: We order countries according to their region group in this chart. Buffer is an estimate/headroom that is not explicitly allocated to any specific application. MENA = Middle East & North Africa, RoW = Rest of the World.

# Application Mix of Energy Storage Projects Deployed Annually Based on Power Output



Source: BloombergNEF Note: Excludes pumped hydro projects. At a project level, if multiple applications are selected, the capacity is divided equally among them. Energy shifting refers to using utility scale energy storage to perform arbitrage and to provide reliable capacity to meet peak system demand.

# Technology Mix of Commissioned Utility-scale Energy Storage Projects Based on Power Output



Source: BloombergNEF. Note: CAES = compressed air energy storage projects. Chart excludes pumped hydro projects. If a project includes multiple technologies, the capacity is divided equally among them.



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## Battery Energy Storage Systems (BESS)



# ESS Driving Renewable Energy Growth

Solar Energy



Wind Energy



ESS



## Residential

- Compliments rooftop solar
- Provides backup power
- Saves money



## Commercial

- Compliments co-located solar and/or wind
- Power reliability
- Saves money



## Utility

- Grid flexibility
- Grid reliability & resilience
- Reducing renewable energy curtailment



# BESS: System Components

Cell

Module

Rack

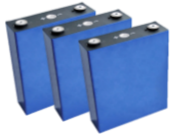
Container

PCS

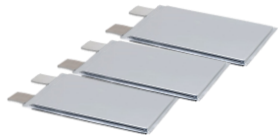
Cell



Cylindrical cell

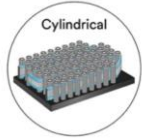


Prismatic cell

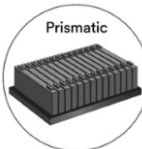


Pouch (polymer) cell

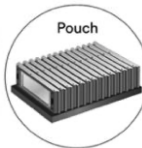
Cell Module Assembly



Cylindrical



Prismatic



Pouch

Module



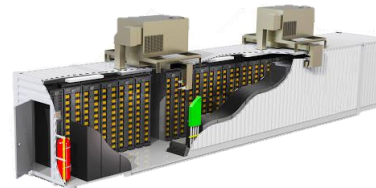
Rack



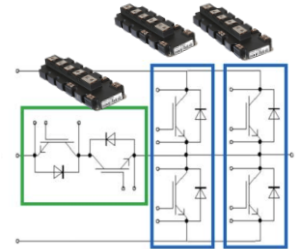
Container



Inside View of Container



Power Conversion System (Bi-directional Inverter)



# Battery Energy Storage System Architectures

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Ac  
Alternating Current

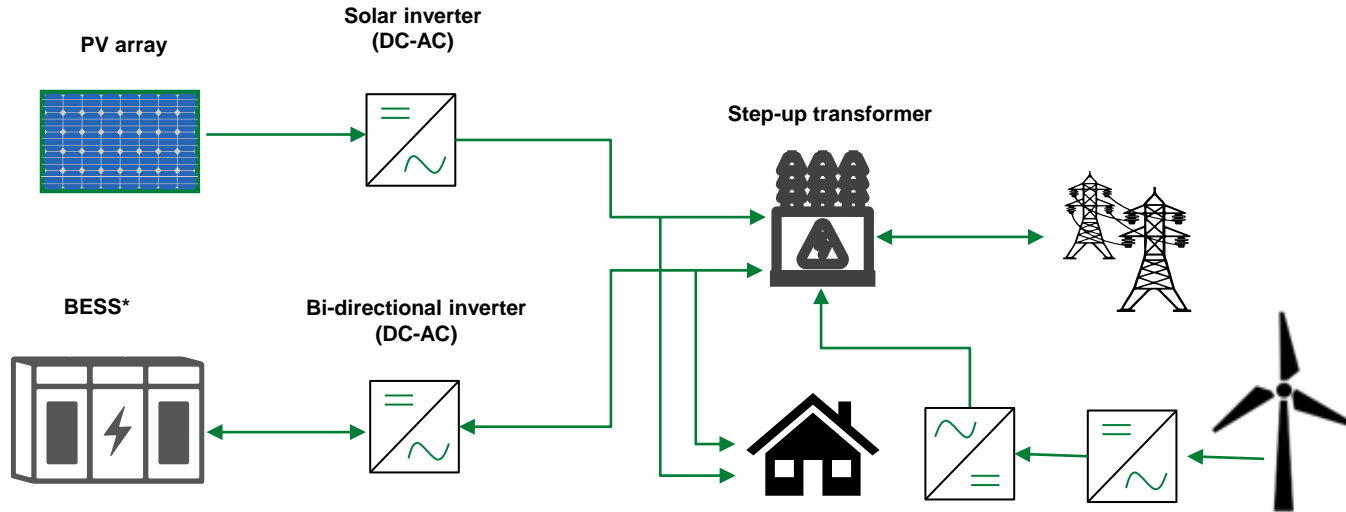


Dc  
Direct Current



# Battery Energy Storage System Architectures

## AC Coupled Solar System



### Acronyms:

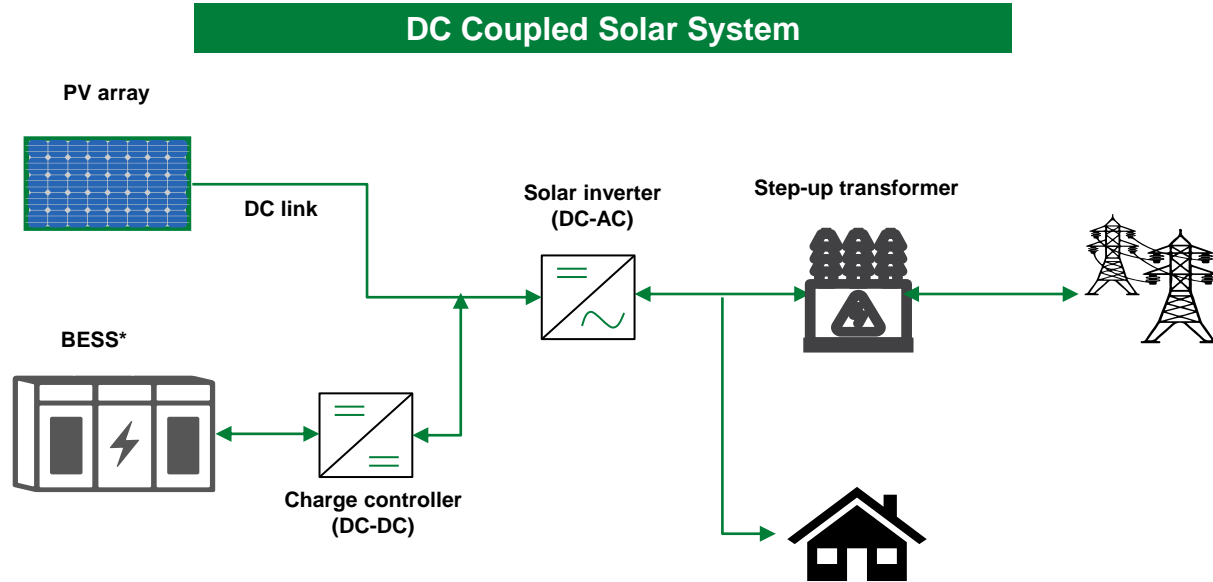
BEES: battery energy storage system

AC: alternate current

PV: photovoltaic

DC: direct current

# Battery Energy Storage System Architectures



**Acronyms:**

*BESS:* battery energy storage system

*AC:* alternate current

*PV:* photovoltaic

*DC:* direct current

# Maximum Return on Investment for Energy Storage Systems

- Maximum Uptime
  - System Reliability
    - Robust system design
    - Reliable components
    - Properly-sized components (circuit protection)
      - Protect equipment
      - Prevent faults from being catastrophic
      - Prevent nuisance tripping
- Optimize Asset Usage
  - Managing asset size and capacity usage
  - Designing for the appropriate use case



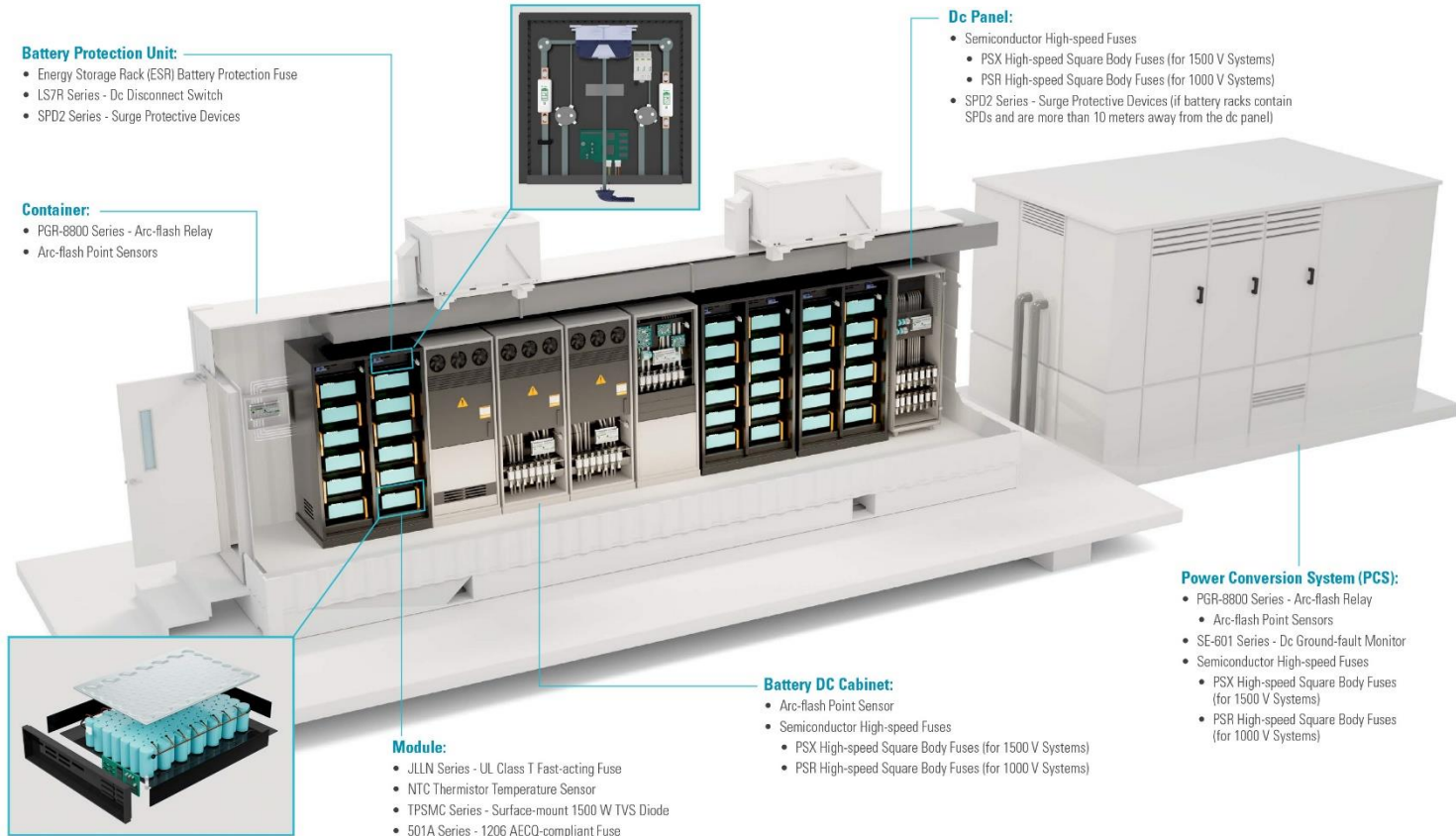
# Cost of Energy Storage System Downtime

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As of Q2 2022 the US has installed 6.5GW/16.8GWh of energy storage\*\*

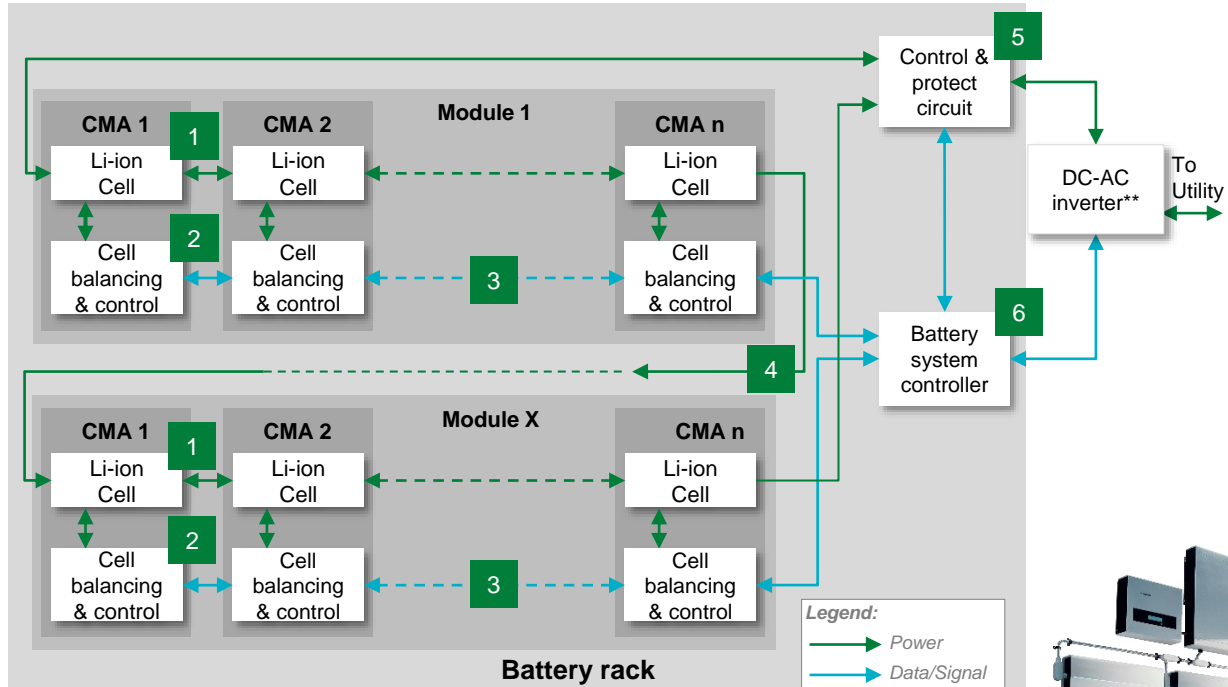
- Assumptions:
  - 58% is used in energy or peak shaving (3.8GW/9.74GWh)
  - Average 1-hour downtime/month
  - 12 hours per year or 45.6GWh/year
  - 1 kWh is \$0.39\* at peak demand
- Total cost:  $(45.6 \times 1000000) \text{ kWh} \times \$0.39 = \$17.78\text{M}$
- Let us assume a five-year guaranteed operation of this system
- $\$17.78\text{M} \times 5 \text{ years} = \text{\$88.9 M contract loss}$

# Circuit Protection Products for BESS Systems





# BESS Architecture for Residential\* and Commercial (Single Battery Rack)



\* Residential BESS has similar architecture, but the # of packs will be limited depending on the kVA ratings

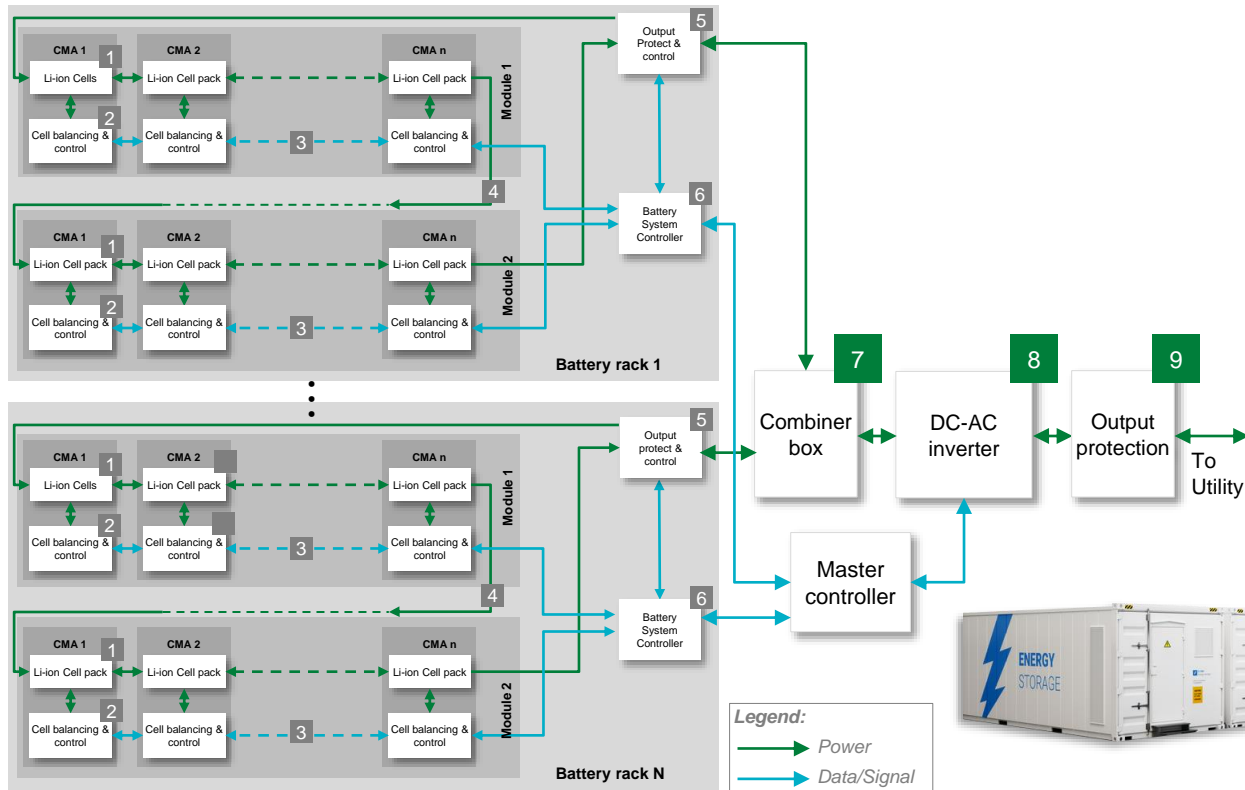
\*\* Large industrial or utility scale BESS system, multiple battery racks are stacked together through a combiner box

\*\*\* Arc Flash Relays are used in large commercial and higher applications



	Technology
1	Fuse
	Temperature sensor
2	SMD or In-line fuse
	TVS diode
3	Diode array
	TVS diode
4	Fuse
5	High-speed fuse
	MOSFET
	Gate driver
	HVDC contractor relays
	Arc flash relays***
6	DC Disconnect Switch
	Diode array
	Fuse
	TVS diode

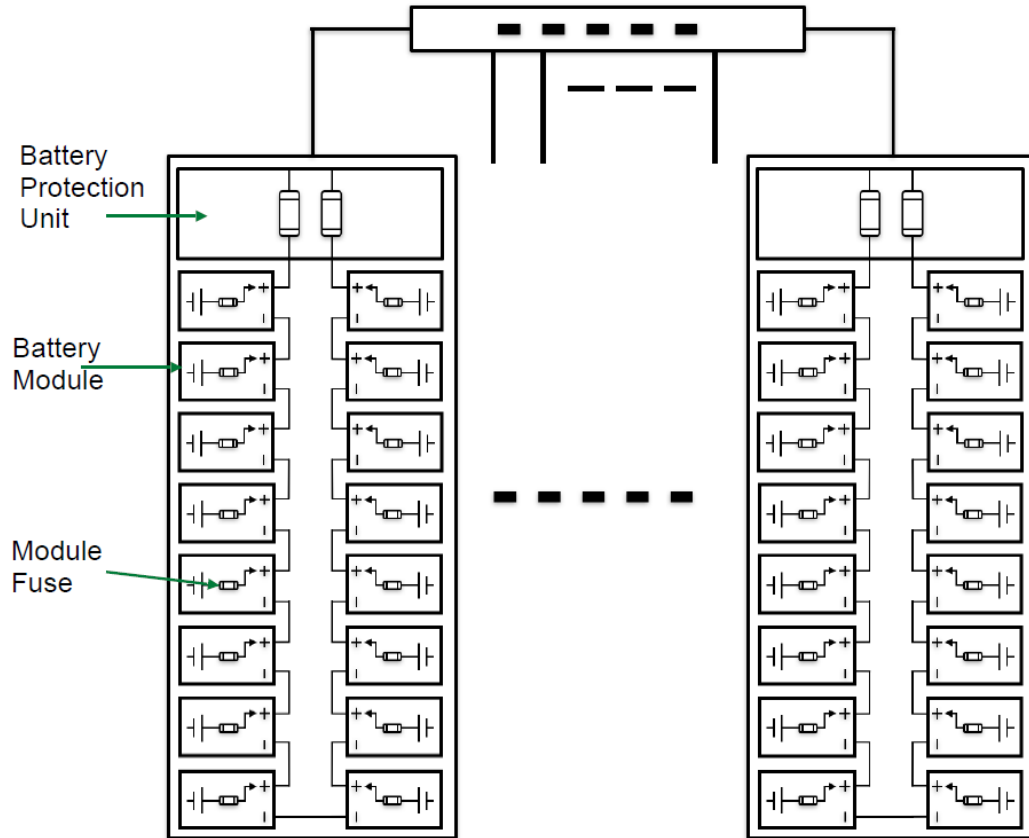
# BESS Architecture for Large Industrial and Utility Scale (Multiple Battery Racks Connected)



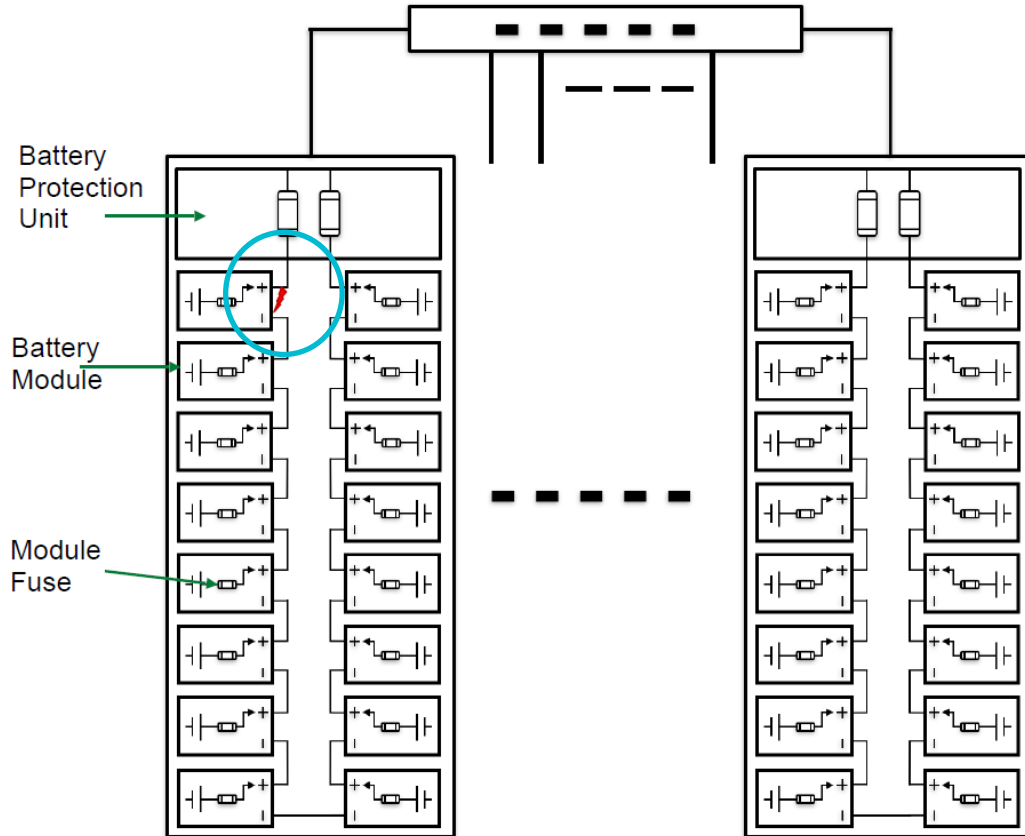
Technology	
7	High-speed fuse SPD (DC link)
8	High-speed fuse Ground fault relay IGBT module
9	Fuse SPD (AC link)



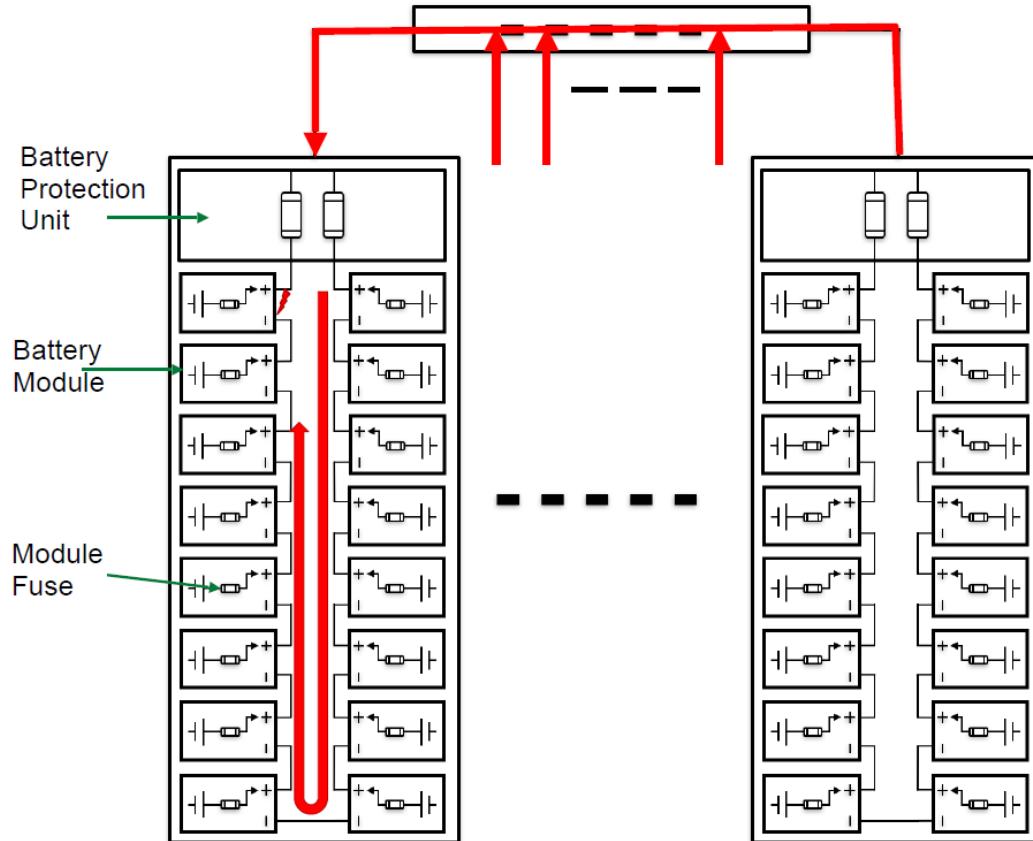
# Fuse Protection and Coordination at the Rack



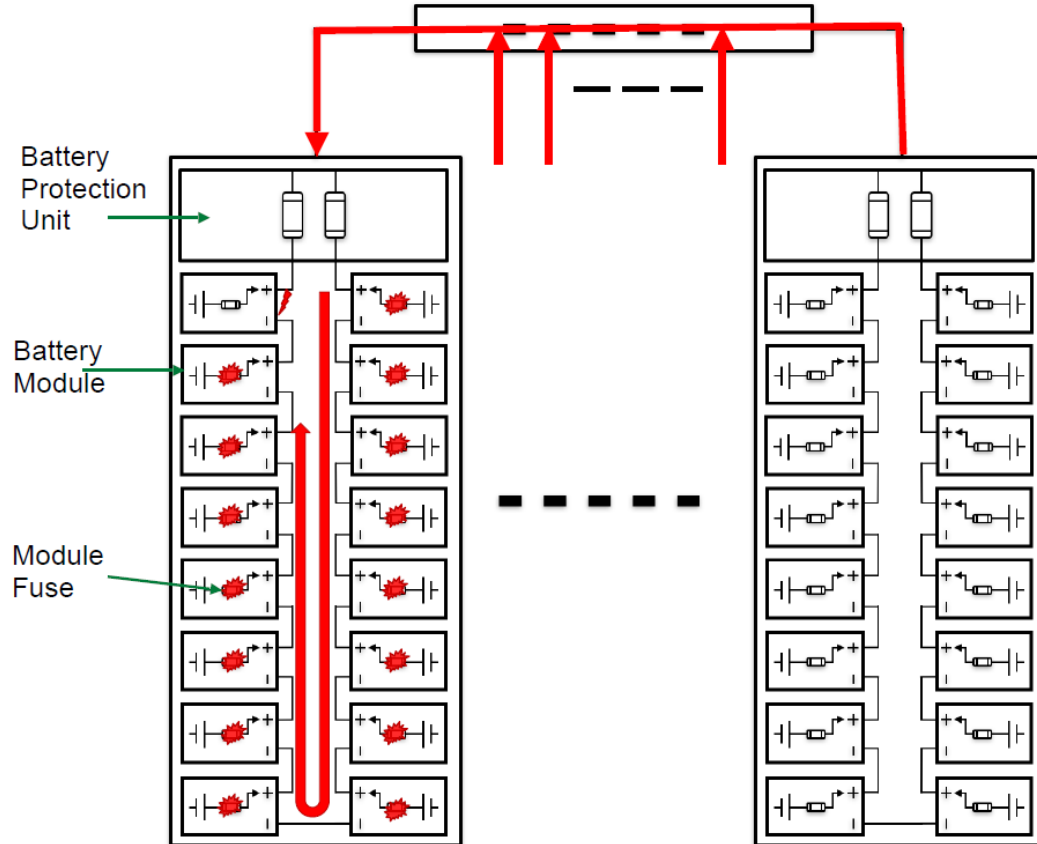
# Fuse Protection and Coordination at the Rack



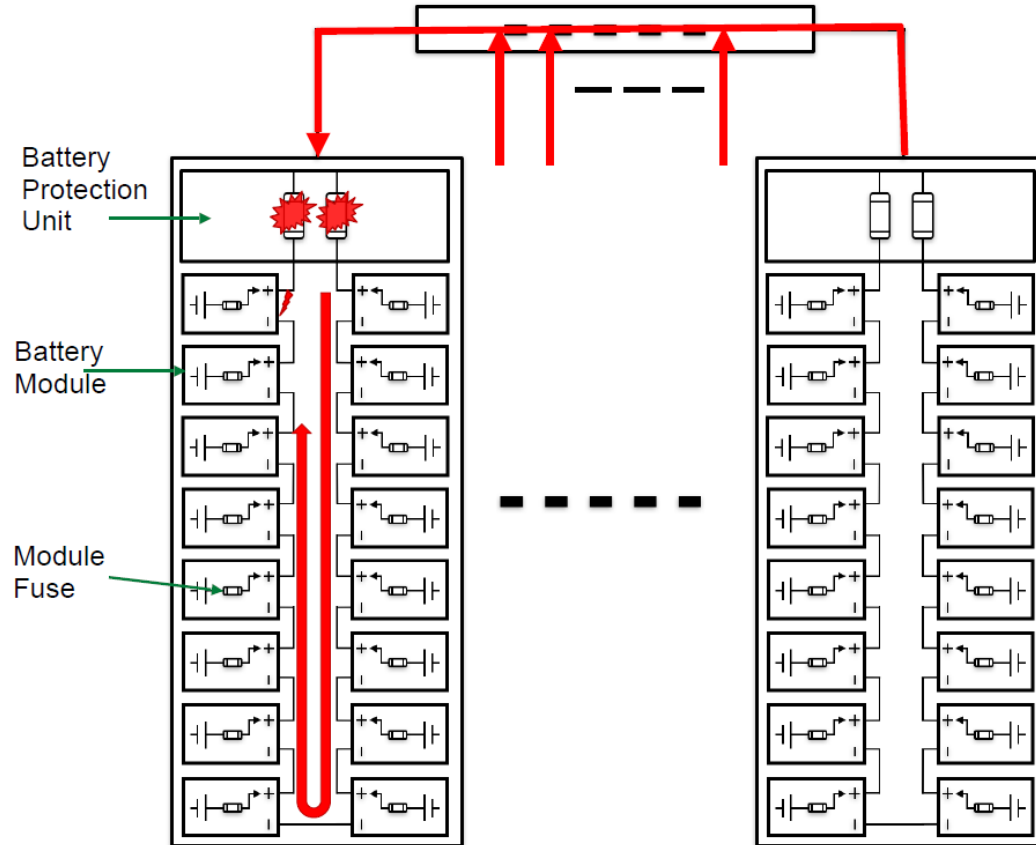
# Fuse Protection and Coordination at the Rack



# Fuse Protection and Coordination at the Rack



# Fuse Protection and Coordination at the Rack





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## Case Studies



# Case Study – High-speed Fuse Prevents ESS Failure

- **Industry:** Energy Storage Systems
- **Application:** Solar/ESS Inverter Protection
- **Customer:** OEM
- **End Users:** State utility companies invested in solar/ESS, micro-grids, community solar, commercial solar power investors, IT infrastructure
- **Required Ratings:** 160 A and 630 A, 1000 V dc
- **Customer Need:** 1000 V dc high-speed fuse with high dc interrupting rating (> 100 kA) along with UL certification
- **Products Designed-in:** PSR flush-end high-speed semiconductor fuses
- **Main reason for PSR Series product selection:**
  - 1000 V dc rated fuses
  - 150 kA dc interrupting rating
  - UL and IEC certifications
  - Dc information available on product label



PSR Series



# Case Study – Packing in More Power with the Right Fuse Protection

- **Industry:** Energy storage systems
- **Application:** Battery bank
- **Customer:** Integrator
- **End Users:** Utility
- **Customer Need:** Higher-capacity battery pack protection
- **Product Designed-in:** PSX high-speed square-body semiconductor fuses
- **Main reason for PSX Series product selection:**
  - 250 kA dc interrupting rating
  - Extremely fast-acting fuse
  - High dc voltage rating up to 1500 V dc



## PSX Series

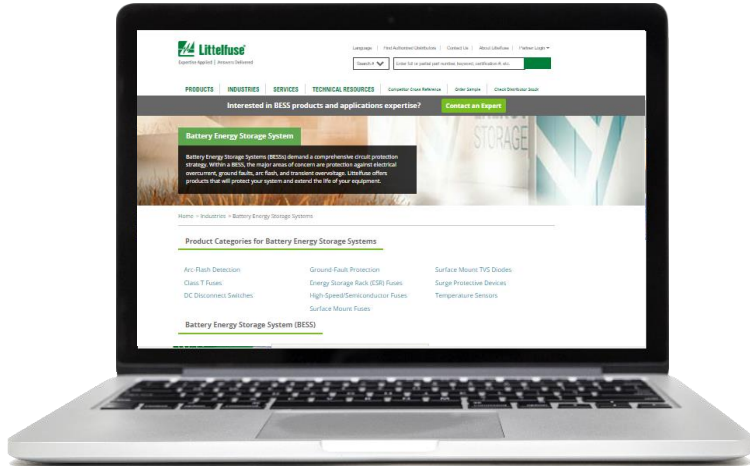


# Conclusion

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- The battery energy storage market is a rapidly growing market
- When selecting an architecture, reviewing the pros and cons of different systems will save time and costs over the long run
- To have a reliable system, a robust system design, and dependable, properly-sized components are necessary
- Proper circuit protection at all levels of a system, facilitates a more efficient architecture, increases reliability, and reduces downtime
- Battery energy storage systems demand a comprehensive circuit protection strategy to maximize return on investment
- Littelfuse can work with companies to establish the right circuit protection strategy through engineer-to-engineer engagement and comprehensive testing tailored to their systems

# Q&A and Additional Information



Expertise Applied | Answers Delivered

Thank you!

Live Q&A

For more information including white papers, educational videos, application guides, and technical specifications visit [Littelfuse.com/BESS](https://www.littelfuse.com/BESS)

If you have technical questions post webinar, please contact Immanuel Umenei at [Iumenei@Littelfuse.com](mailto:Iumenei@Littelfuse.com)



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## Q&A



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by Emiliano Bellini



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## **Monday, 12 December 2022**

7:00 am – 8:00 am CET, Berlin, Paris, Madrid  
2:00 pm – 3:00 pm AWST, Perth

## **Wednesday, 18 January 2023**

1:00 pm – 2:00 pm EST, New York City  
7:00 pm – 8:00 pm CET, Berlin, Paris, Madrid

**Many more to come!**

**Understanding  
Australia's  
tantalizing  
battery market**

**Hail risk in  
solar: Identify,  
quantify, and  
mitigate**

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