Introduction to Storage and PV integrations for Utility-Scale and C&I

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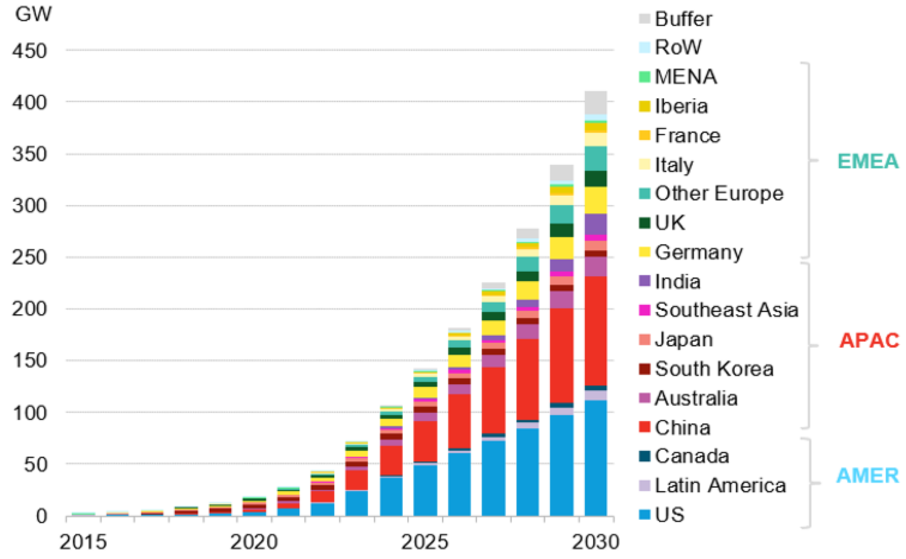
Innovative Power Solutions

1. Introduction, market insight

- Global forecast to 2030:
  - > Rapid growth thanks to adoption of renewable energy
  - > Battery price **divided by 4** in the last 10 years
  - > Energy Storage is booming
  - > USA & China are the main markets (100GW each within 2030)

Source: BloombergNEF

Figure 1: Global cumulative energy storage installations, 2015-2030



Source: BloombergNEF.

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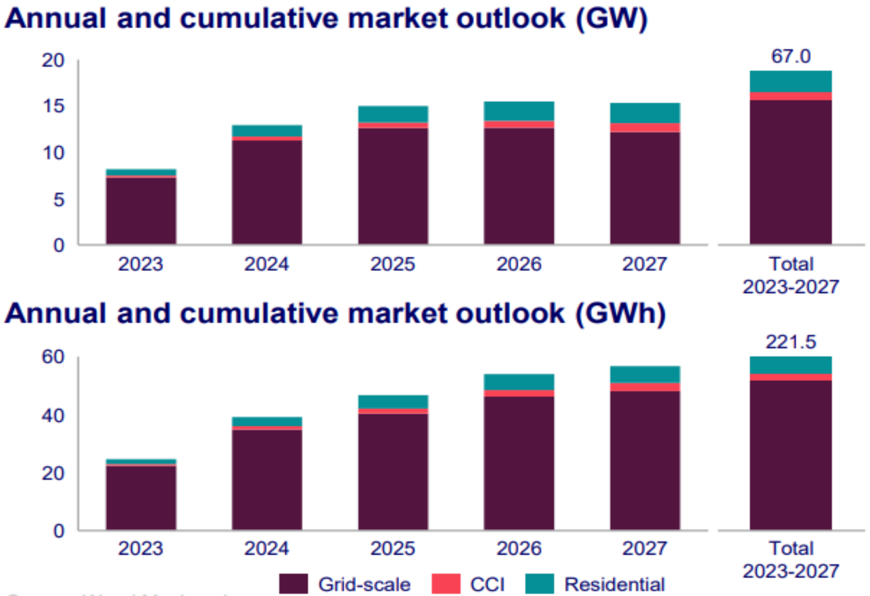
1. Introduction, market insight

US energy storage five-year market outlook

- US forecast:
  - > **Inflation Reduction Act** is playing a major role in the BESS market growth
  - > Forecast capacity increases, important capacity jump from 2023 to 2024
  - > Utility Scale represents the main market
  - > while C&I and Residential still important market and represent numerous of smaller power projects.



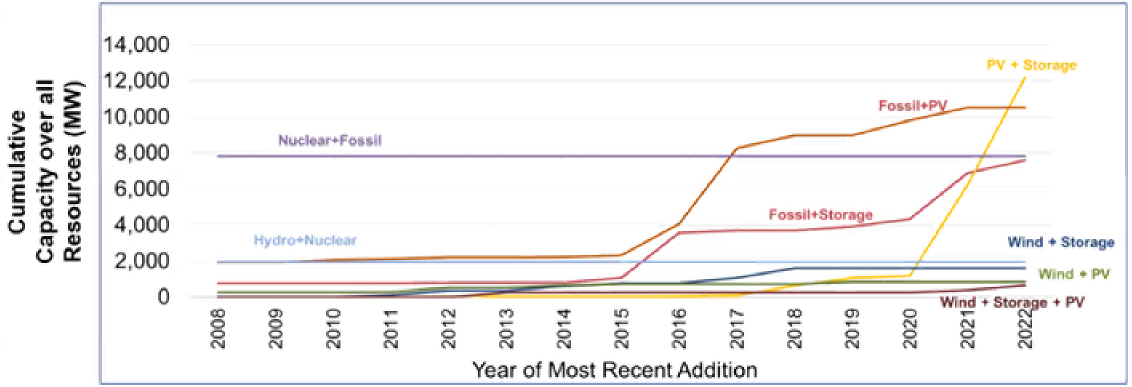
Source: Wood Mackenzie

Wood Mackenzie

1. Introduction, market insight

- **Adoption of Storage with PV:**
  - > PV + Storage growing faster than any other combined generation and storage
  - > Storage adds new revenues streams
  - > Incentives for PV + Storage stimulates this market

Growth of combined generation and storage capacities for key hybrid types overtime

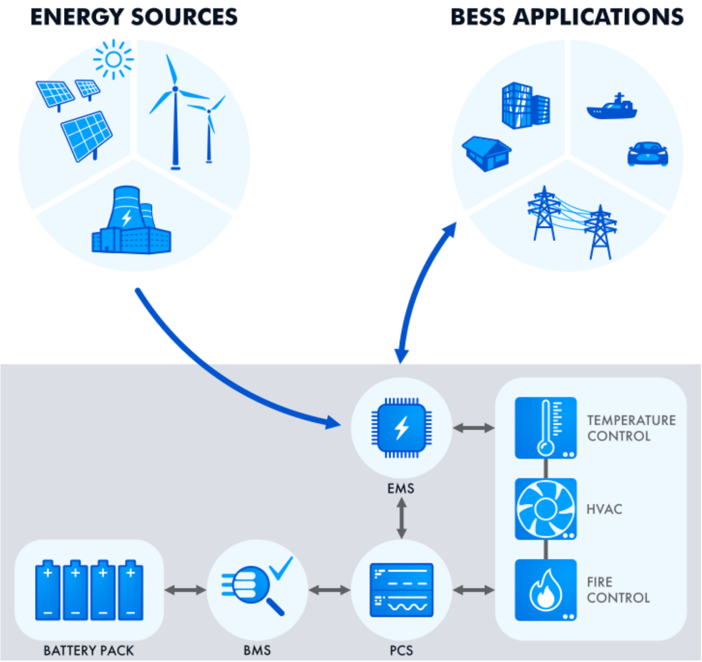


Ignored types: (1) Fossil+PV+Storage, (2) Fossil+Storage+Wind+PV, (3) Fossil+Wind+Storage, (4) Fossil+Wind+PV, (5) Fossil+Wind, (6) Biomass+PV, (7) Geothermal+PV+CSP, (8) Geothermal+PV, (9) Hydro+Storage, (10) Biomass+Storage, (11) Hydro+Biomass

Sources: EIA 860 2022 Early Release, Berkeley Lab

2. Energy storage integration with PV

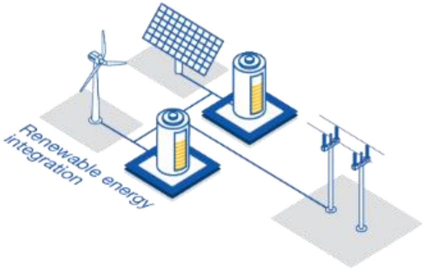
- **Overview of BESS components:**
  > Batteries:
    » Technologies: LFP, NMC…
    » Cells
    » Modules
    » Racks
  > Battery Management System (BMS):
    » Ensures safe and efficient operation of batteries
  > Power Control System (PCS):
    » Power Electronics
    » Inverters, converters, etc.
  > Energy Management System (EMS):
    » The intelligence of how the whole system interact with external informations
  > Cooling/Heating and Fire Safety Systems:
    » Ensure the system stays within operational limits.
    » Ensure the right level of safety and fire protection according the standards.



- **BESS Integration with PV:**
  > Point of Connection: How and where the BESS integrates into the solar setup.
  > Sizing Considerations: Based on load profiles, peak shaving, load shifting, etc.
  > Interplay between PV and BESS: How they complement each other.

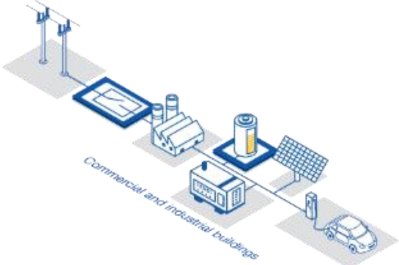
2. Energy storage integration with PV

REN energy integration



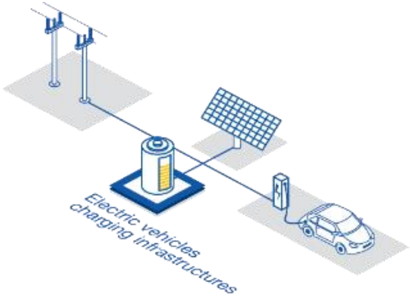
- Solar plants
- Community Solar
- Agrivoltaic
- Wind Turbines

Commercial & Industrial



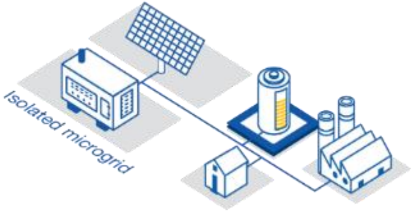
- Offices
- Industries
- Public buildings
- Shopping Malls

EV charging infrastructures



- Solar canopies
- Fleet of vehicules
- EV Charging Stations
- Transport Hub with parking

Isolated microgrid

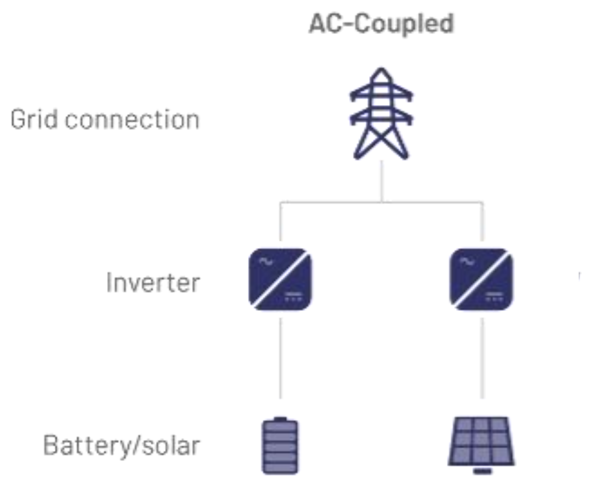


- Industries
- Hotel & Resort
- Rural Electrification
- Island Electrification

3. AC-coupled Storage with PV

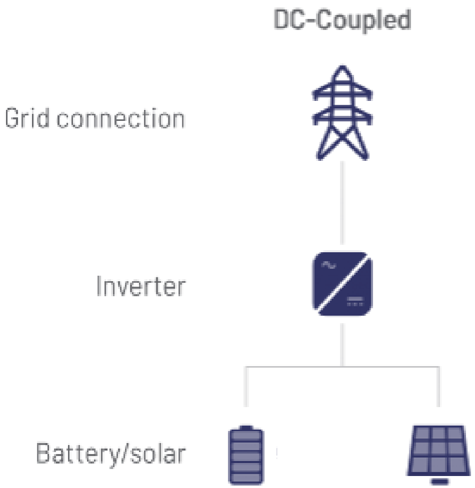
- <u>Benefits:</u>
  - > **Retrofitting**: AC-coupled batteries are easy to install on an existing solar panel system, and more can be added to expand capacity.
  - > **Flexibility**: Installers are not restricted in where the inverters and batteries can be located.
  - > **Independent**: Storage system can operate independently of the PV system, offering more varied use-cases.
  - > **Resiliency**: Having multiple inverters provides more combined power and battery faults do not have an impact on power generation.
  - > **Versatility**: AC-coupled systems enable batteries to charge from the grid as well as from the solar panels, so if the solar panels are not generating enough electricity, the battery can still charge from the grid.

- <u>Challenges:</u>
  - > **Cost**: AC-coupled systems cost more than DC-coupled systems as they use multiple inverters.
  - > **Lower efficiency / Conversion losses**: The stored energy is converted three times, from the DC current to AC current to supply then from AC to DC current to the battery and again back into AC to the grid.
  - > **Complex Grid Interactions**: Ensuring seamless interaction with the grid, especially during high-demand periods, requires meticulous management and more advanced EMS



4. DC-coupled Storage with PV

- Benefits:
  - > **Higher efficiency:** Unlike AC systems which convert the current multiple times, DC coupled systems only convert the current once, reducing energy losses and making them more efficient (6% to 8% increase)
  - > **Affordability**: DC-coupled systems tend to be cheaper than AC-coupled systems as the solar panels and battery use a single inverter and less extra equipment such as voltage transformers and switchgear.
  - > **Oversizing**: DC-coupled systems allow solar panels to generate more electricity than the inverter rating. The excess energy can be used to charge the battery



- Challenges:
  - > **System Balance:** Ensuring the correct sizing of the battery and PV system is crucial.
  - > **Less resiliency**: With a single inverter in a DC-coupled system, if the inverter fails, the solar power as well as the battery capacity is lost.
  - > **Interdependent:** PV and storage are Interdependent
  - > **Limited flexibility:** Installers have less flexibility than with an AC system, as the inverter needs to be located close to the battery.

5. How BESS addresses critical grid challenges

REN integration

Anticipate regulations thanks to a mostly renewable energy mix.

Energy cost saving

Erase your consumption peaks and optimize your REN production without significant additional costs.

Grid reinforcement

Develop new uses, including electric mobility, without touching the grid network

Grid resilience

Limit your dependency on grid and downtime

CO^2 emission reduction

Reduce significantly your carbon footprint and take the lead in raising consciousness.

5. How BESS addresses critical grid challenges

Storage Services		Categories	Functions
ESS1	Peak Shaving	Saving money Services	Limit peak demand to a defined level
ESS2	Load Shifting		Shift energy consumption from one point in time to another
ESS3	Self-Consumption		Maximize consumption of electricity produced locally
ESS4	Price Arbitrage		Optimize energy prices in a volatile market
ESS5	Reactive power compensation		Compensate reactive power consumptions by loads
ESS6	Power Back-up	UPS Services	Secure power supply
ESS7	Power Quality		Guarantee power quality
ESS8	Demand Response	Grid Services	Adapt energy consumption according to a grid demand
ESS9	Capacity Reserve		Guarantee an electrical capacity to secure the grid
ESS10	Grid Stabilization		Help to stabilize the grid in frequency and voltage
ESS11	Transmission & Distribution Support		Limit power carried in electrical cables
ESS12	Isolated microgrid	Off-Grid Services	Manage off-grid functions for microgrid
ESS13	Renewable Integration	REN Services	Optimize REN production and grid integration
ESS14	EV Recharging	EV Services	Optimize EV recharging capacity during specific times slots

6. Preparing to engage with a BESS supplier

- **Project Objectives:**
  - > What's the primary goal? (grid stabilization, peak shaving, price arbitrage, backup power, etc.)
  - > Duration of storage needed.
  - > Desired system lifespan and warranty considerations.

- **Load Profiles:**
  - > Historical and forecasted load data.
  - > Peak demand periods.
  - > Seasonal variations.
  - > Critical loads to be supported.

- **Grid code compliance:**
  - > Understand local and regional grid codes.
  - > Are there specific standards the BESS needs to meet?

- **Technical Specifications:**
  - > Integration with existing infrastructure (PV systems, EVCI, gensets etc...).
  - > On-grid or/and Off-grid operations
  - > Need for remote monitoring and control capabilities.
  - > Maintenance and service agreements.

- **Site Assessment:**
  - > Physical location and space availability.
  - > Environmental conditions (temperature, humidity, salinity if near coasts).
  - > Accessibility for installation and maintenance.

- **Budget Constraints:**
  - > Total project budget.
  - > Potential for incentives or subsidies.
  - > Cost-benefit analysis based on project objectives.

6. Preparing to engage with a BESS supplier

SYSTEMS
NFPA 1, NFPA 70 (NEC), NFPA 855-2023 / IFC
UL9540-2020 / FCC 15 Part A
UL 1741 PCS CRD (4 modes)

INSTALLATIONS
NFPA 1, 70 (NEC), 855 / IFC
Seismic study (anchoring)

BATTERIES
UL1973
UN38.3 / UN3841
UL9540A (Cells / Modules / Units)
IFC / NFPA 855-2023

CONVERTERS
UL 1741 SB 3rd Edition
UL 1741 PCS CRD (4 modes)
IEEE 1547-2018 / IEEE 1547.1-2020
IEEE 1547a-2020
Rule 21 (CA) / HI Rule 14h

INTERCONNECTIONS
IEEE 1547-2018 / IEEE 1547.1-2020
IEEE 1547.2 / IEEE 1547.9-2022
Rule 21 (CA) / Rule 14h

LOCAL LISTING
SGIP / CEC / HECO

Q&A

thank you SO much!