ALL ABOUT THAT BESS: BATTERY GLOSSARY

enspired

the glossary

This dictionary is your personal go-to guide for all terminology related to battery energy storage systems (BESS). From the basics to the complexities, the glossary foregoes wordy definitions and explains 86 terms and abbreviations in a simple and illustrative manner.

category 1:

the very basics

BESS - Battery Energy Storage System
Rechargeable battery that stores power provided from various energy sources for later use. The system can be discharged as needed for grid support and backup power.

Grid
Network of power lines for the transmission and distribution of energy over a geographical area.

Source: entsoe

category 2:

specs & status

SoC - State of Charge
The capacity a battery has available for use. SoC indicates how full or empty the battery is.

SoH - State of Health
The battery's ability to retain capacity compared to its rated value before use. SoH signals how much a battery degrades over time.

DC & AC - direct/alternating current
The two types of electrical current. DC can be converted to AC and vice versa. What makes the two kinds different from one another is the flow of the electrical charge.

DC (one-directional) is used for
- batteries in electronic devices such as smartphones and laptops
- special applications like custom motors
- electronic circuits and components such as transistors and microchips

AC (bi-directional) is used for
- power lines supplying households, businesses and industries
- long-distance transmissions
- machines of any size

→ Battery systems can be both AC- and DC-coupled.

Degradation
The gradual decline of battery capacity and performance over time. Charging and discharging cycles prompt chemical reactions in the battery material, causing changes in the asset's structure that affect storage capabilities and energy deliverability. Other contributing factors include operating temperature and (dis)charging rates.

Maximum charge/discharge
Mechanism to maximize battery life by not discharging below 10% and not charging above 90%.

DoD - Depth of Discharge
Percentage of energy discharged from a battery's total capacity. To maintain battery health, the DoD should not be higher than 90%.

Energy rating
The amount of energy a battery can store and release, typically measured in kWh or MWh. The duration of supply depends on the energy consumption of the device the battery powers.

RTE - Round Trip Efficiency
Percentage of energy deliverd by the battery when discharging compared to the energy supplied to the battery when charging.

Warranty terms
Manufacturer conditions and compliance policies governing the performance, capacity, material and operational limitations of a battery. Examples of typical BESS warranty terms include:

Label	Value	Description
Room temperature range	20-27 °C	ambient temperature should be between 20-27 degrees Celsius
Average state of charge (SoC)	<50% yearly average	the average SoC should be kept below 50%
Total throughput	10,000 MWh	total amount of energy the asset can store and provide throughout its lifetime (usually given in conjunction with a yearly limit)
Warranty duration	10 years	the manufacturer guarantees asset performance and functionality for a period of 10 years if warranty terms are adhered to

Inverter
The BESS component that converts direct current (DC) output into alternating current (AC) electricity to make the power suitable for the grid and electrical devices.

Cycle
The process of charging and discharging a battery energy storage system. One cycle is completed when the asset is charged to the allowed maximum and discharged to the allowed minimum. A battery's lifespan is determined by the number of cycles it can undergo while upholding satisfactory performance standards. The total lifetime is typically expressed in Full Cycle Equivalents (FCE).

FCE - Full Cycle Equivalent
Sum of (dis)charge events that amount to one full charge (from 0-100%) and one full discharge (from 100-0%) of a BESS. In other words, partial cycles can be added up to reach one or more FCEs.

Capacity retention
Expressed in %, this metric measures how efficient a battery is in holding a charge after repeated (dis)charge cycles.

Coloumb/Faraday efficiency
Ratio of the total charge drawn from a battery to the total charge supplied to a battery over a complete cycle.

Throughput
The total amount of energy a battery can store and provide throughout a defined period of time (e.g. daily, yearly, lifespan), typically expressed in kilowatt-hours (kWh) or megawatt-hours (MWh). In other words, throughput indicates how many (dis)charging cycles a battery can undergo without major loss of performance.

Ramp rate
Indicates how fast an asset can change its electrical output. As batteries are highly rapid in their reactivity, TSO and DSOs are often limiting this speed to keep the grid stable and unaffacted by sudden drops or increases in output.

Ramp rate control
The ability to adapt the speed at which a battery changes its power output. As the grid is very sensitive to sudden changes in supply, ramp rate control helps maintain stability in a smooth and gradual manner.

C-rate - charge/discharge rate
Rate at which a battery is charged or discharged, relative to its total capacity. A battery's C-rate indicates how quickly it can supply or absorb energy. Expressed as a unitless value, it typically comes in C/x or xC format, with x signalling how much capacity can be (dis)charged per hour.

Here are some examples

- C-rate of 1C for a 1 MWh battery:

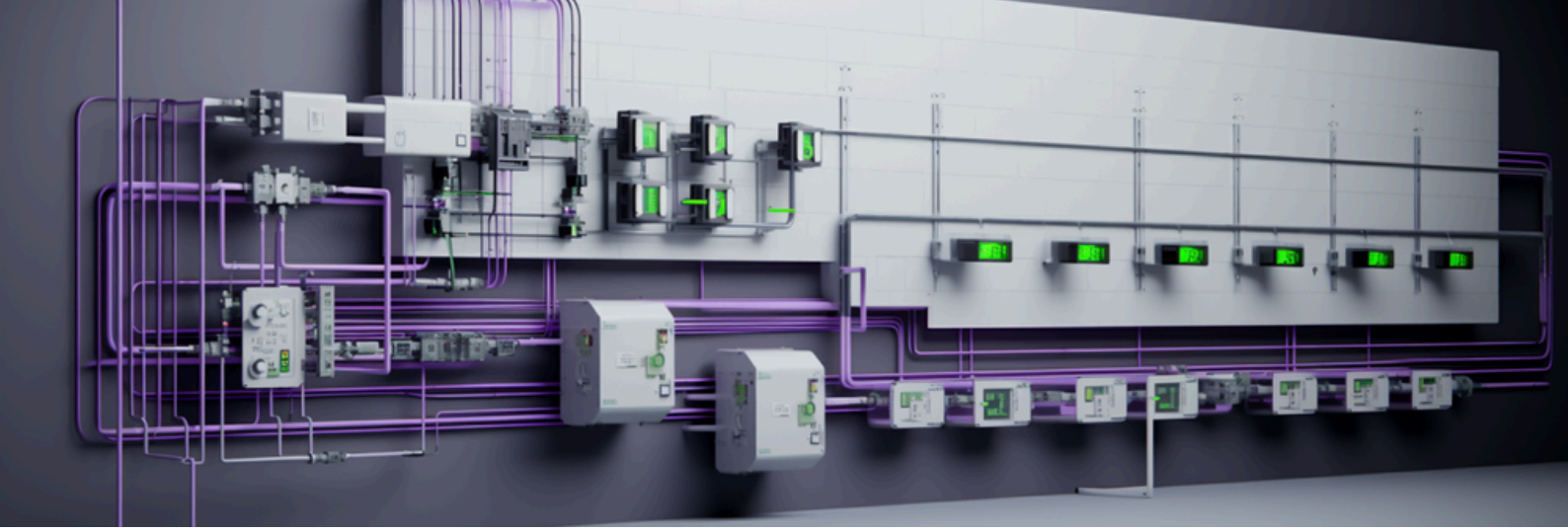
the asset (dis)charges at a rate of 1 MWh per hour -> it takes 1 hour to (dis)charge fully

- C-rate of 0.5C for a 1 MWh battery:

the asset (dis)charges at a rate of 0.5 MWh per hour -> it takes 2 hours to (dis)charge fully

- C-rate of 4C for a 1 MWh battery:

the asset (dis)charges at a rate of 4 MWh per hour -> it takes 15 minutes to (dis)charge fully



category 3:

components

Cell

Electrochemical device that converts chemical into electrical energy. A cell is the most basic form a battery can take. It consists of a positive (cathode) and a negative (anode) electrode. Their external connection points (terminals) are separated by an electrolyte causing ions and electrons to move between the terminals (from **+** to **-** when discharging and from **-** to **+** when charging).

→ This generates current and voltage, which allows the asset to operate.

Module

Cluster of individual cells connected in a specific configuration to achieve the desired performance characteristics.

Rack

Physical structure that contains and organizes the modules and cells within a battery system.

Switchgear

Equipment for managing and protecting the inner-system electrical power flow.

PCS - Power Conversion System

Technical component that ensures the flow of energy between a BESS and connected loads such as the power grid.

HVAC (heating, ventilation, air conditioning) concept

Design to regulate the temperature and air quality inside a battery. A proper cooling system must be in place to keep the asset from overheating.

category 4:

control & units

BMS - Battery Management System

Control hub that manages battery properties within the BESS. It

- monitors SoC & SoH
- balances the energy supply of individual cells and modules, adjusting charging rates if necessary
- optimizes charging processes to prevent battery damage due to over- or undercharging
- surveils battery temperature to take appropriate actions when there is a chance of overheating
- detects system errors and provides diagnostic information for maintenance and troubleshooting
- logs relevant data for performance analysis, optimization and predictive maintenance
- implements safety measures (e.g. cell disconnection or system shutdown) to counteract risks like thermal runaway, which can cause explosions
- integrates communication protocols for status reports and command transmissions between different management and grid systems

EMS - Energy Management System

Mechanism to schedule and control BESS application and activity.

API - Application Programming Interface

Intersystem communication protocol that analyses and coordinates BESS operation with respect to involved third-party applications.

Utility meter

Device that measures the amount of utilities - such as eletricity or water - consumed by an industrial, residential or commercial user. Meter and utility meter are often used interchangeably.

kW - kilowatt (1000 watts)
MW - megawatt (1 million watts)
GW - gigawatt (1 billion watts)

Units of power measuring at which rate energy is being produced or consumed. The kW/MW/GW specification indicates how much power a battery can absorb or provide.

kWh - kilowatt-hour
MWh - megawatt-hour
GWh - gigawatt-hour

Units of power measuring at which rate energy is being produced or consumed per hour. The kWh/MWh/GWh specification indicates how much power a battery can absorb or provide in a 1-hour time window.

category 5:

use cases

Frequency regulation
Automated adjustment of BESS power output to keep grid frequency at a consistent 50 Hz.

Load shifting
Coordinating a battery's energy usage patterns with low price rates. This means moving BESS charging times to non-peak hours to save money while consumption stays the same. For instance, 3pm likely offers better prices than 9am as morning household demand will have died down considerably by then. Conversely, the battery is discharged during hours with high prices to maximize earnings.

Peak shaving
Reducing BESS energy use during expensive consumption windows. Peak shaving is about consuming less to save costs. At the same time, batteries can also be employed to compensate for peak shaving use cases of other assets.

Ancillary services
Support functions provided to the electricity grid to ensure stability, reliable power supply and renewable integration. These services include:

- frequency containment
- frequency restoration
- replacement reserves
- voltage and reactive power control
- congestion management
- redispatch

Demand response
Grid support with consumption units such as batteries or washing machines. It involves the adjusting of energy consumption in response to a signal from the TSO. For example, several aggregated shopping malls can react to a prompt for grid relief by temporarily turning off heavy power-consuming machines.

Black start capability
Ability to reactivate (parts of) a power system like the grid in the event of a blackout.

Redispatch
Amendment to the nominated output schedule of a BESS or power plant by the TSO.

Voltage and reactive power control
Keeping the pressure that pushes electricity steady and securing the "behind-the-scenes" energy needed to perform this task.

category 6:

setup & technology

Grid-scale battery
A large BESS with direct connection to the power grid.

BTM - behind-the-meter
Energy system on the end consumer's side of the utility meter. BTM refers to all residential power assets, from solar panels on the roof of a family home to a Tesla Powerwall in the basement.

FTM - front-of-the-meter
Energy system on the utility or grid side of the meter, typically power plants, wind farms or large-scale battery storage. FTM battery activities are separately metered, whereas BTM logs only total consumption.

Standalone battery
Independent containerized storage units, usually charged through the grid during off-peak times but not connected to other types of generation such as solar or wind.

Renewable integration
Share of power in the grid that comes from renewable sources. The advancement of the energy transition depends on a sustainable, flexible electricity system, and batteries are among the main facilitators for it.

Co-located battery
A battery storage facility installed alongside a second energy producing unit, especially solar generation. Please note that the term 'co-located' should be treated as a developing concept as it is currently a subject of disagreement and controversy.

Battery pooling
Aggregation of multiple single battery systems into one large virtual unit. It can be thought of as VPP consisting solely of batteries.

C&I (commercial & industrial) battery
BESS designed for commercial use. Such an asset is meant to support a core activity of an industrial setting like a factory, school, office, hospital or data center.

Overdimensioned battery
A commercial battery unit with more capacity than what is needed for the intended use or purpose in an industrial setting. The leftover capacity is ideally suited for revenue diversification in the markets.

DER - distributed energy resources
Individual small-scale energy assets and technologies that can be aggregated within a localized area for broad application (VPP). Examples include solar panels, wind turbines, CHPs (combined heat and power) and storage systems.

LDES - long-duration energy storage
BESS designed to provide energy for extended periods of time, typically hours or days, compared to the shorter, more traditional durations.

VPP - virtual power plant
Aggregation of several independent energy assets such as BESS, solar and wind into one virtual unit.

V2G - vehicle-to-grid
Electric vehicle batteries utilized in a streamlined (dis)charging infrastructure to create a mobile storage network with direct connection to the power grid.

FCR - Frequency Containment Reserve
Primary reserve market to address grid fluctuations.
It helps maintain balance between supply and demand.

aFRR - Automated Frequency Restoration Reserve
Secondary reserve market. It automatically reinstates the balance between electricity supply and demand following a grid disturbance.

mFRR - Manual Frequency Restoration Reserve
On-demand emergency supply service the TSO can activate to reinstate the balance between electricity supply and demand following a grid disturbance. It serves as the tertiary reserve market.

Intraday auction
Marketplace where battery capacity can be traded for the same day.

Day-ahead auction
Marketplace where battery capacity can be traded for the next day.

WS - wholesale
Marketplace where battery capacity can be traded in bulk quantities for different time periods and various applications. WS branches include day-ahead and intraday auctions, which can be stacked with other revenue streams such as ancillary services to ensure diversification.

TSO - Transmission System Operator
Entity responsible for reliably transmitting energy in bulk from power plants to distributors and users through the electrical grid. The TSO is responsible for keeping the grid stable at a frequency of 50 Hz at all times. For this purpose, ancillary services act in a supportive function to WS.

DSO - Distribution System Operator
Entity responsible for reliably transmitting energy to end consumers. While TSOs work long-distance and large-scale, DSOs are more localized and low-voltage.

Benchmarking
Comparing costs, performance and other relevant metrics of energy assets, companies or technologies to identify opportunities for optimization.

Forecasting
The process of predicting future pricing, demand and supply in the energy market based on relevant data to develop the best trading strategy for BESS commercialization.

Rebalancing factor
Ratio of traded and physically dispatched battery capacity. Let's simplify this and say you sell energy for 100€, and then the price drops to 60€ - in this scenario, it would be more cost-effective to buy the amount you sold in the market instead of producing it for dispatch.

Balancing mechanism
Market that balances electricity supply and demand for each 30-minute trading period.

category 8:

financial

LCOE - Levelized Cost of Energy
Metric for cost assessment and comparison of electricity generation from different sources for the duration of a project.

Inefficiency factor
Metric for the loss of performance due to battery charging and discharging processes.

CapEx - capital expenditure
Total investment required to develop and commission a BESS project, including asset acquisition and infrastructure procurement.

OpEx - operating expenditure
Total cost associated with the operation, management and upkeep of a battery project after its launch.

Innovation tender
Formal call for the development of a BESS project with specific requirements. Suitable providers can then submit their bid to enter a pool of candidates, from which one will be selected to realize the project.

Bankability
The ability to make money. When a BESS project meets the requirements to be granted financing, it is considered 'bankable'.

Floor price
Guaranteed revenue minimum for a commodity (e.g. electricity). Battery operators with a floor price in their trading agreement are guaranteed a minimum amount of money they will gain from their asset. However, the overall revenue split is lower because the market risk gets transferred to the trading party.

Fully merchant
100% at the mercy of market conditions. Battery owners who take their asset fully merchant, carry all of the market risk but keep a bigger revenue share.

Tolling agreement
Long-term contract between a toller (seller) and an offtaker (renter). The toller operates the BESS (including permits, site control, maintenance etc), and the offtaker supplies the electricity to charge it. This entitles the offtaker to exert control over how the stored energy is used, while the toller has limited discharging privileges. More on tolling agreements and floor prices here.

category 9:

sustainability

Second-life battery
BESS assets that have retired from their original function to fulfill a new one. For example, a battery from an electric vehicle can be repurposed for stationary applications.

Green battery
A BESS produced with minimal environmental impact and for sustainable operability. Examples include thermal, flow and gravity batteries.

Discarding
End of life management for a BESS. It is important to know how the asset will be disposed of once it's reached the end of its lifespan. Exhausted batteries can be

- disassembled
- recycled
- used for research
- given a second life
- collected by regulated waste disposal services

Recycling
Safe disassembly of a battery to recover valuable components for reuse in compatible applications.

category 10:

representatives

EASE - European Association for Storage of Energy
Leading member-supported association representing organizations across the entire energy storage value chain in Europe. EASE supports the deployment of energy storage to facilitate the cost-effective transition to a cleaner energy system.

IEA - International Energy Agency
International organization working with countries around the world to shape energy policies for a sustainable and secure future.

IRENA - International Renewable Energy Agency
Intergovernmental organization supporting countries in their transition to a cleaner energy system.

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