AN INTRODUCTION TO BATTERY ENERGY STORAGE SYSTEMS (BESS)

A FlexGen White Paper

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BATTERY ENERGY STORAGE SYSTEMS (BESS)

By definition, a battery energy storage system (BESS) is an electrochemical apparatus that uses a battery to store and distribute electricity.

A BESS can charge its reserve capacity with power supplied from the utility grid or a separate energy source before discharging the electricity to its end consumer.

The number of large-scale battery energy storage systems installed in the US has **grown exponentially in the early 2020s,** with significant amounts of additional reserve capacity in development.

This increase in BESS adoption is largely being pushed forward by utilities, electric cooperatives, and independent power producers.

BESS FOR ELECTRIC UTILITIES & ELECTRIC CO-OPERATIVES

Battery energy storage systems help utilities and electric cooperatives easily integrate intermittent renewable resources like **wind and solar** into their power generation portfolios.

With BESS and renewable power generation, electricity providers can move toward further **reducing local carbon emissions, increasing grid resilience,** and providing customers or co-op members with more reliable access to electricity.

During peak demand hours, battery storage systems can be discharged to regulate,

balance, and stabilize the energy grid. By charging batteries during periods of low customer consumption, co-ops, municipalities, and utilities can **reduce the cost of energy they provide.** In areas with increasing populations and ever-growing demand loads, BESS can be installed without additional transmission lines.

If extreme weather or a natural disaster has temporarily disrupted a consistent grid power supply, isolating outages and discharging batteries can also **help utilities and co-ops ensure their customers' or members' critical loads - like heating, lighting, and other life-sustaining devices - are not interrupted.**

BESS FOR INDEPENDENT POWER PRODUCERS

Whether using wind, solar, or another resource, battery storage systems are a very valuable supplement to any diversified energy portfolio for independent power producers (IPPs) selling electricity to utilities, co-ops, and end-consumers. **Battery systems help IPPs balance power outputs and schedule discharges to efficiently manage their energy and increase potential revenues.**

With controls and automation provided by an energy management system (EMS), IPPs can use value stacking to create multiple revenue streams.

Beyond selling the stored electricity itself, IPPs with battery energy storage systems can add value with ancillary and distribution services like voltage support, frequency regulation, demand charge management, and more.

2 HOW BESS WORK

The most important component of a battery energy storage system is the battery itself, which stores electricity as potential chemical energy.

Although there are several battery technologies in use and development today (such as lead-acid and flow batteries), **the majority of large-scale electricity storage systems utilize lithium-ion chemistry for increased grid resiliency and sustainability.**

2.1 LITHIUM-ION BATTERIES

From your electric toothbrush to your electric vehicle, lithium-ion (Li-ion) batteries are manufactured in a wide variety of chemistries, capacities, and capabilities. While handheld devices like cell phones may utilize lithium cobalt oxide (LCO) batteries, **there are three primary Li-ion chemistries** used to reliably store residential, commercial, and utility-scale electricity.

Li-ion Chemistry	Description
Lithium Iron Phosphate (LFP)	LFP batteries are the preferred choice for grid-level electricity storage and can also be used in smaller applications.
Lithium Nickel Manganese Cobalt Oxide (NMC)	More energy dense than LFP, NMC batteries are frequently used in home solar systems, power tools, and electric vehicles (EVs) as well as utility-level storage.
Lithium Nickel Cobalt Aluminum Oxide (NCA)	Even denser than NMC chemistry, NCA batteries are typically found in higher-end performance EVs like the Tesla Model X.

Built to endure high load currents with a long cycle life, lithium iron phosphate (LFP) batteries are designed to handle utility-scale renewable power generation and energy storage capacities up to **several hundred megawatt-hours.** Without nickel or cobalt, LFP devices are **less dense and cheaper to manufacture than NMC and NCA batteries,** making them best suited for large installations where space is less constrained.

2.2. BESS HARDWARE

Battery energy storage systems are installed with several hardware components and hazard-prevention features to safely and reliably charge, store, and discharge electricity.

Inverters or Power Conversion Systems (PCS)

The direct current (DC) output of battery energy storage systems must be converted to alternating current (AC) before it can travel through most transmission and distribution networks. With a bidirectional power conversion system (PCS), BESS can charge and discharge electricity to and from the energy grid.

Medium Voltage Transformers (MVT)

Before the AC power from the PCS can be transmitted into the grid, the output must be matched to the voltage level of the BESS collection system. A medium voltage transformer (MVT), often mounted directly on the PCS skid, is used to step up the electrical output to the appropriate voltage level. The output of each MVT on the site is then combined and transmitted into the grid.

Heating, Ventilation, and Air Conditioning (HVAC)

When a battery is charged or discharged, the internal resistance of the cells causes thermal energy to be released, creating heat that must be properly managed to keep systems in service. With sufficient ventilation, air conditioning, liquid cooling, and other solutions, HVAC systems prevent BESS overheating and ensure ongoing performance.

Fire Protection

To help prevent and control events of thermal runaway, all battery energy storage systems are installed with fire protection features. Common safety components include fire-rated walls and ceilings, fire alarm control panels, deflagration panels, smoke, heat, and gas detectors, dry-pipe water sprinklers, and chemical fire suppressants.

2.3 BESS SOFTWARE

Critical for ongoing safety and system performance, software and digital controls help BESS operators monitor and manage the movement of electricity throughout a battery energy storage system.

By using intelligent, data-driven, and fast-acting software, **BESS can be optimized for power efficiency,** load shifting, grid resiliency, energy trading, emergency response, and other project goals

Communication: The components of a battery energy storage system communicate with one another through TCP/IP (Transmission Control Protocol/Internet Protocol), connected to a shared network via ethernet, fiber optic cables, cellular data, or satellite.

Monitoring: BESS software processes real-time energy data and displays it in a human-machine interface (HMI) dashboard so that the information can be viewed remotely at any time.

Real-time optimization: Behind the scenes, intelligent BESS software continuously produces and executes corrective output commands to ensure that the system is always running in optimized conditions.

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ENERGY MANAGEMENT SYSTEMS (EMS)

Connecting the hardware and software components of modern BESS, energy management systems (EMS) allow utilities and independent power producers to **monitor, control, and optimize their energy assets while working towards project goals.**

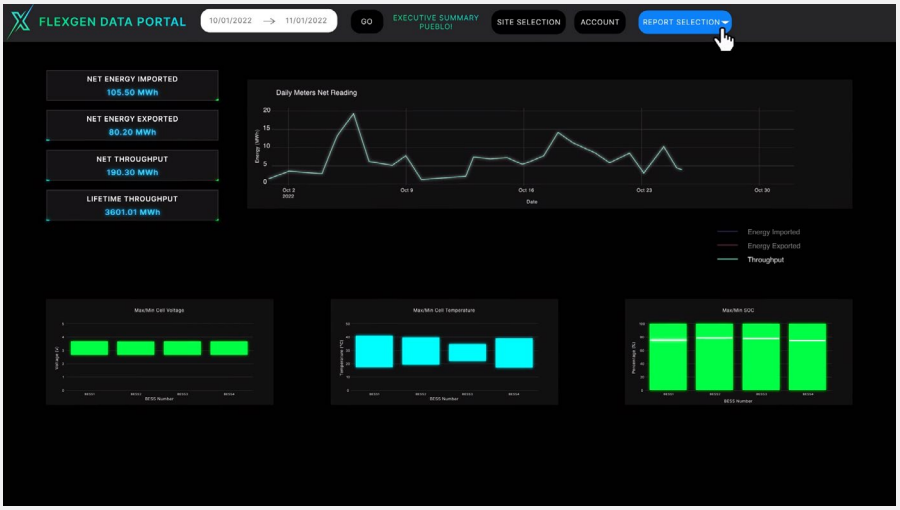
Integrating renewable power production, battery storage, and grid transmissions into one central platform, **BESS operators can use an EMS to track the real-time performance and efficiency** of their system's energy and financial activities.

Compared to rugged PLCs (programmable logic controllers) and PPCs (power plant controllers) alone, **EMS platforms enable more comprehensive management of battery energy storage systems** through detailed reporting and analysis of energy production, reserve capacity, and distribution.

Equipped with a responsive EMS, battery energy storage systems can analyze new information as it happens to maintain optimal performance throughout variable operating conditions or while integrating new components into an expanding system.

FlexGen Energy Management Systems

FlexGen's HybridOS software is a hardware-agnostic EMS platform for battery energy storage systems. **HybridOS enables multi-source and multi-site energy management**



for peak BESS performance with instantaneous monitoring, web-based controls, and automated APIs.

Protected physically and digitally, FlexGen HybridOS systems follow **multi-level NERC security protocols** while powering installations with remote 24/7 surveillance and on-site training for field service dispatch and project developers.

Backed by industry-leading experience, multiple patents, unmatched bankability, and a proven **uptime of 99.7%** during extreme weather events, consider FlexGen to be your partner in battery energy storage systems.

Tell us about your project today.