Battery Energy Storage System Best Practices Guide for Commercial and Industrial Buildings

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1. Executive Summary

This Battery Energy Storage System (BESS) Best Practices Guide provides essential guidelines for the safe and efficient installation and operation of Battery Energy Storage Systems in various building types across British Columbia. This guide is essential for commercial property owners, contractors, and installers, ensuring compliance with safety standards and optimizing BESS performance.

The guidance in this publication applies to commercial/light industrial (C&I), including mixed-use buildings in British Columbia. Building types not listed are beyond the scope of this guide. Additionally, only systems with a total capacity of under 5 MWh, is considered, and the guide does not consider storage units used as uninterruptible power supplies or UPS units.

The key points included in the guide are information on:

- Safety and Compliance: Details on the safety measures such as proper ventilation, fire suppression systems, emergency disconnects, and adherence to relevant codes and standards (e.g., UL, CSA, NFPA) required for the installation.
- Installation and Integration: Procedures for selecting qualified contractors and installers, choosing appropriate battery systems, and integrating BESS into different building types, ensuring optimal performance and safety.
- Operations and Maintenance (O&M): Highlights the importance of regular monitoring, preventative maintenance, and corrective actions to maximize the lifespan and efficiency of the BESS.
- Economic and Environmental Benefits: Encourages the adoption of BESS through BC Hydro's incentive programs, promoting energy resiliency, cost savings, renewable energy integration, and backup power capabilities.
- End-of-Life Management: Guidance on the proper disposal and recycling of BESS units.

Specifically, the guide provides procedures for installation and long-term operation of BESS that will be installed for **behind-the-meter** operation. Behind-the-meter refers to energy storage systems that are connected on the /business owner’s side of the electrical meter. A business owner could use a BESS to shift electrical load, improve power quality, or better manage peak loads as a part of the several BC Hydro program offerings explored in the guide.

This guide is a vital tool for ensuring that BESS installations are conducted safely, efficiently, and in compliance with all relevant standards, supporting BC Hydro's commitment to sustainable energy solutions. The guide will outline the steps for customers to secure a qualified contractor and provide the information needed to collaborate with their contractor.

The contractor will assist the owner in identifying the most suitable battery solution for their needs. It is important to note that the guide does not endorse any specific battery manufacturer, contractor, or installer.

It is important to note that each BESS installation project presents unique conditions. Hence, the recommendations provided in the guide are general best practice techniques, which will need to be adapted as per unique needs of a project.

2. Key Terms and Definitions

The following are key terms and definitions that will aid the owner in understanding the BESSs:

- “Active Power” – the actual power which is really transferred to the load.
- “Alternating Current” (AC) - An electric current that periodically reverses direction and changes its magnitude continuously with time.
- “Apparent Power” – the combination of reactive power and active power.
- “Battery Energy Storage System” (BESS) – An electrochemical storage device capable of delivering or absorbing electrical energy at its DC bus.
- “Battery module” – An assembly of rechargeable battery cells with a convenient mechanical arrangement and a degree of protection.
- “Battery rack” – A free-standing assembly of battery modules, integrated as part of an overall BESS.
- “Battery Thermal Management System” (Battery TMS) – controls the temperature of the cells according to their specifications. The system may use heating, ventilation, and air conditioning (HVAC) or liquid cooling systems to achieve safe operating temperatures.
- “Behind the Meter” – Components that are located on a customer’s premises. It is a jurisdictional area which has different governing area than its counterpart “front of the meter”. Front of the meter would include distribution, transmission and large-scale generation infrastructure.
- “Calendar Life” – The expected number of calendar years that the battery is expected to last if it were unused.
- “Current Transformer” (CT) – An instrument transformer used to step down a measured current for metering, control or protection purposes.
- “Degradation” – The permanent reduction in in the amount of energy a battery can store, or the amount of the power it can deliver.
- “Depth of Discharge” (DOD) – The ratio of the amount of energy discharged from the BESS to the maximum dischargeable energy capacity of the BESS.
- “Direct Current” (DC) – an electric current that flows in one direction. Output directly from a battery is an example of DC current.
- “Electrical Panel Busbars” (Busbar) – A metallic bar used to carry electric power from incoming feeders and distribute it to outgoing feeders.
- “End of Life” (EOL) – The defined remaining BESS capacity as a percentage of the amount of initial BESS capacity at which the BESS system becomes not functional as initially designed.

- “Energy management system” (EMS) – The EMS is the top-level system controller, responsible for system power flow control, management, and distribution.
- “Energy Storage System” (ESS) – One or more components assembled capable of storing energy and providing electrical energy into the premises wiring system or an electric power production and distribution network.
- “High Voltage Direct Current” (HVDC) – Aan electric power transmission system that uses direct current (DC) for electric power transmission.
- “Human Machine Interface” (HMI) – A user interface that serves as the main point of interaction between an operator of the battery plant and the settings, functions and commands associated with the plant.
- “Lead Acid Battery” – A type of rechargeable battery that uses lead dioxide (PbO2) as the positive plate, sponge lead (Pb) as the negative plate, and a diluted sulfuric acid solution as the electrolyte.
- “Lithium-ion Battery” (LiB) – A type of rechargeable battery that use lithium-ions as the primary components of its electrolyte.
- “Lithium Iron Phosphate” (LFP) – A type of LiB that uses lithium iron phosphate as a cathode in its cell structure.
- “Nominal Capacity” – The rated capacity (in Ah or kWh) of the battery as provided by the manufacturer.
- “Operations and Maintenance” (O&M) – A comprehensive approach to managing physical assets and infrastructure within an organization.
- “Power Conversion System” (PCS) – The PCS is the power interface from the Battery system to the AC electrical grid.
- “Power factor correction” (PFC) – a technique used to improve the power factor of AC circuits by reducing reactive power.
- “Qualified Electrical Worker” (QEW) – One who has demonstrated skill and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved.
- “Reactive Power” – the power that is absorbed and returned in a load due to its reactive properties, such as inductance and capacitance.
- “Round Trip Efficiency” (RTE) – Ratio between the energy supplied to the storage system and the energy retrieved from it.
- “SCADA”- The Supervisory Control and Data Acquisition system that facilitates the communication between networked components within the battery energy storage system.
- “State of Charge” (SOC) – The ratio of present dischargeable energy storage capacity to maximum dischargeable energy storage capacity expressed in percentage (%).

- “State of Health” (SOH) – The ratio of the current condition of the energy storage system on a potential stored energy capacity compared to its original specification.
- “Technical Safety BC” (TSBC) – The authority that oversee the installation and operation of equipment and systems in BC that are subject to specific rules and safety guidelines under the Safety Standards Act and Railway Safety Act.
- “Thermal Runaway” – When a battery's internal temperature rises to a level that initiates a self-sustaining reaction, the temperature continues to increase, potentially leading to the battery venting, catching fire, or even exploding.
- “Usable Capacity” – The usable capacity after accounting for the maximum DoD of the batteries.
- “Vehicle-to-Grid” (V2G) – Defines a technology that allows for the energy stored within the battery of an electric vehicle (EV) to be utilized as power for the electric grid.

3. Energy Storage System Basics

Energy Storage Systems (ESS) refer to devices that can store energy in one form to be used later. The energy can be stored in a variety of forms, including mechanical (pumped hydro), thermal (molten salt), and electrochemical (batteries).

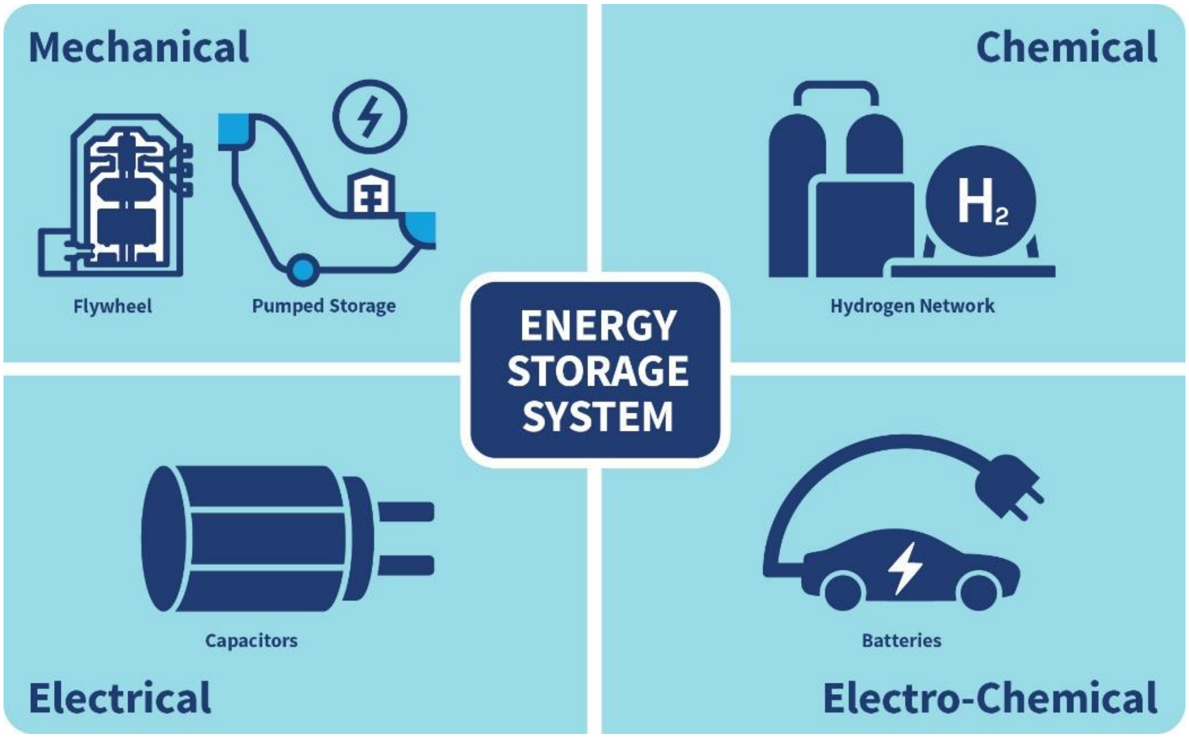

Figure 3-1: Different Energy Storage Systems (Pumped Hydro, Hydrogen Network, Capacitors, and Batteries)

Recent advances in ESS, particularly in electrochemical batteries, have overcome previous land requirements and economic barriers that had prevented wide-scale deployment in commercial buildings.

3.1 Battery Energy Storage System

A Battery Energy Storage System (BESS) is an electrochemical device that acts as an electrical load by consuming electrical energy while charging and then discharges stored energy as electricity when demanded. The source of the charging electricity could be the grid or any energy generating source (e.g., solar panels or wind turbines), and the electricity is stored as chemical energy in the battery.

BESS technologies are flexible, making them effective for a number of applications. They have a wide range of storage and power capacities, allowing for them to be useful for short and long duration applications. The technology is typically modular, occupies smaller space than other energy storage technologies, and has experienced significant cost reductions in recent years.

Utilities are seeking to develop programs to jump-start BESS deployment at all levels with the continuing decline in the BESS prices and the increasing need for grid flexibility due to deployment of renewable energy.

Some key definitions for ratings that should be understood for BESSs are:

- **Power capacity** is the maximum power that a battery can deliver at any given moment. Common units of measurement include kilowatts (kW) or megawatts (MW). Charging and discharging power capacity may differ.
- **Energy capacity** (in kWh/MWh) is the total amount of energy that a battery can store.
- **Storage duration** is the duration for which the battery can supply electricity at its rated power. This is also the ratio of the energy capacity to the power capacity.
- **State of Charge (SOC)** is the percentage of battery capacity that is charged and available to be converted to electricity.

A BESS can supply electricity for a longer period at a lower power rating. For example, a 1 kW/4 kWh system can supply 1 kW for 4 hrs or 0.5 kW for 8 hrs, or 0.25 kW for 16 hrs. Therefore, the power rating determines how fast the BESS can discharge and charge. This needs to be selected based on the application and requirements.

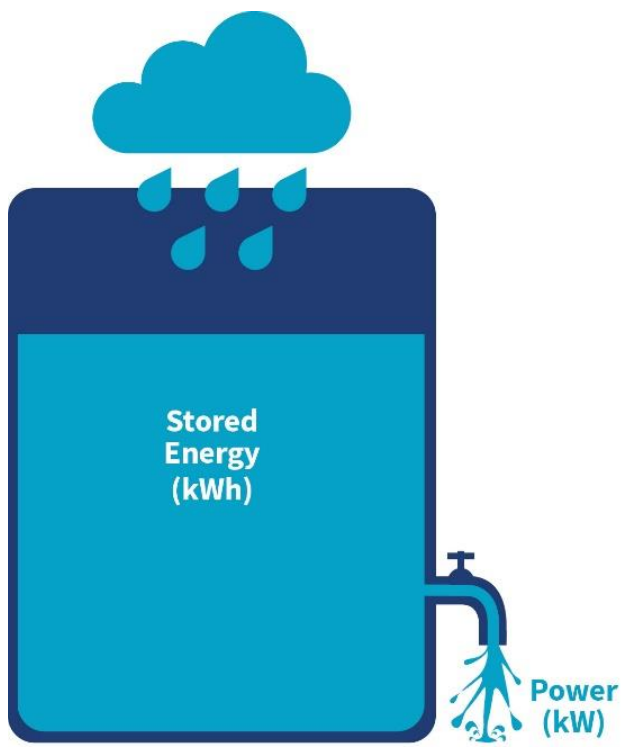

Figure 3-2: Rain Barrel Model Describing Stored Energy and Power of a BESS

3.2 Components of a BESS

A Battery Energy Storage System can generally be divided into the following component categories:

- Core electrochemical battery components.
- Battery auxiliary system components.
- Power electronics components.
- Fire Safety Systems.

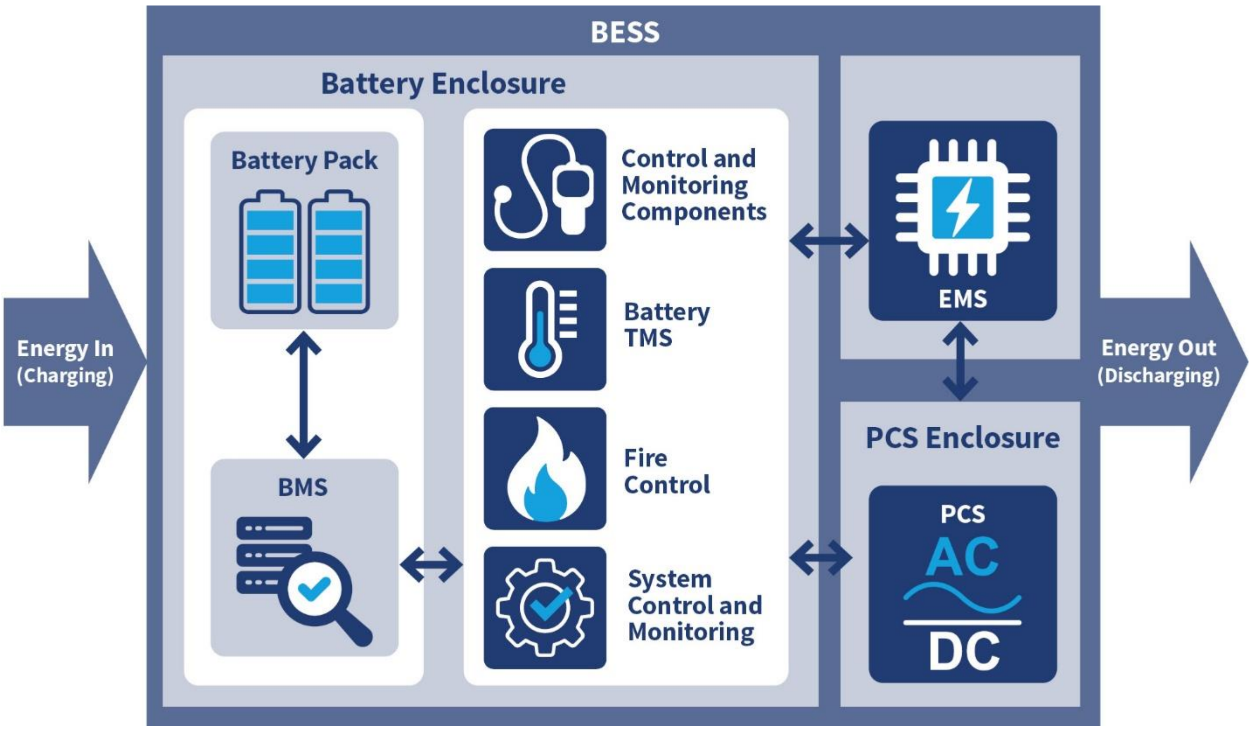

Figure 3-3: Components of a BESS

Table 3-1: Battery Component Descriptions

Category	Component	Component Description
Core Electrochemical Battery Components	Battery Module	Composed of multiple battery packs (which are composed of connected cells), or individual cells, connected to make a particular voltage and capacity. The amount of energy in a battery pack is referred to as capacity, commonly expressed in the units of kilowatt-hours (kWh) and megawatt-hours (MWh).
	Battery Management System (BMS)	The BMS protects the cells from harmful operation, in terms of voltage, temperature, and current, to achieve reliable and safe operation, and balances varying cell states-of-charge (SOCs).
	Battery Thermal Management System (TMS)	The battery TMS controls the temperature of the cells according to their specifications. The system may use heating, ventilation, and air conditioning (HVAC) or liquid cooling systems to achieve safe operating temperatures.
Auxiliary System Components	System control and monitoring	Overall supervisory control and data acquisition (SCADA) system but may also include fire protection or alarm units.
	Energy management system (EMS)	The EMS is the top-level system controller, responsible for system power flow control, management, and distribution.
	Enclosure	Provides a protective and organized enclosure for housing the BESS subsystems. Typically includes specific ratings on dust and moisture protection.
Power Electronics	Power Conversion system (PCS)	This component may be fully separate from other components or may be integrated into the same enclosure. The PCS functions as a rectifier to convert alternating current (AC) power from the grid to direct current (DC) power to charge the battery and an inverter to convert the DC power from the batteries to AC for use by the connected loads.
	Control and monitoring components	Voltage sensing units and thermal management of power electronics components (fan cooling). Control components will need to interface with EMS.
Fire Safety Systems	Fire Control Components	Larger BESS units may have fire control systems built into the unit. These systems offer an additional layer of protection in case of a thermal runaway. Fire control components may include fire suppression systems, ventilation, heat and smoke detectors, and gas detectors.

3.3 Cell Chemistries

There are a variety of different BESS technologies that utilize different chemistries. Each battery has unique advantages and disadvantages. In this guide the focus is on two commercially available BESS chemistries:

- Lead-acid batteries
- Lithium-ion batteries.

3.3.1 Lead-Acid Batteries

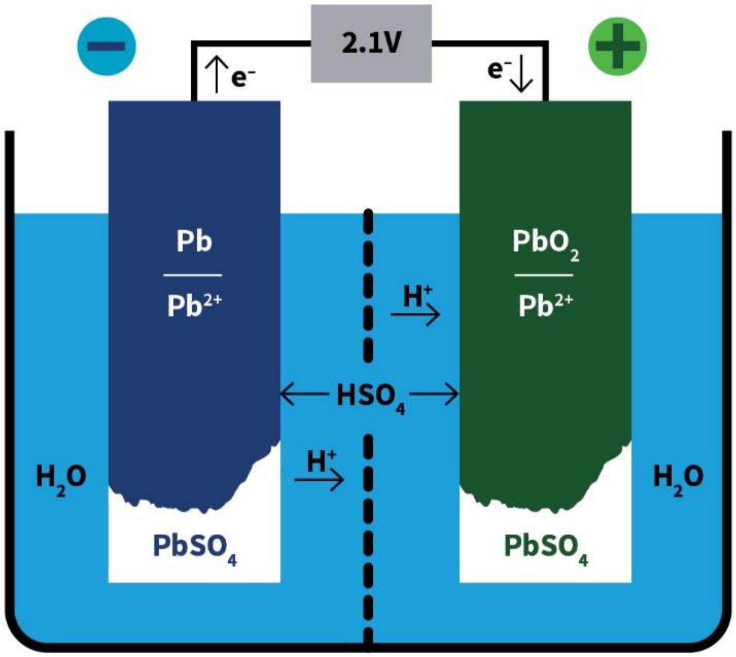

Figure 3-4: Construct of a Lead Acid Battery, Anode, Cathode, Electrolyte

First invented in the 1860s, the lead-acid battery is the oldest rechargeable battery system and has over a century of innovation. It is made with lead electrodes immersed in a sulfuric acid electrolyte to store and release electrical energy. Despite developments in new battery chemistries, they remain one of the most widely used types of batteries due to their reliability, low cost, and relatively simple construction. Typical applications for lead-acid batteries include the following:

- Automotive: used in vehicles for starting, lighting, and ignition systems.
- Mobility: electric scooters, wheelchairs, stairlifts, golf carts, etc.
- Backup Power: uninterruptible power supplies, emergency lighting systems, and telecommunications equipment.
- Renewable Energy Storage: storing excess energy generated by solar panels and wind turbines.
- Industrial: forklifts, industrial cleaning equipment, and other heavy machinery.

Despite their long history, LA batteries have relatively low cycle life, limited energy densities, poor calendar life (will start to self-discharge over time during storage), and their components are hazardous.

Table 3-2: Lead Acid Battery Parameters

Parameter	Value
Energy Density (Wh/L)	80-90
Specific Energy (Wh/kg)	35-40
Charge/discharge efficiency	50-95%
Self-discharge rate (per month)	3% to 20%
Cycle life	~1500
Nominal cell voltage	2.1 V
Environmental Operating Temperatures	-35ºC to 45ºC

3.3.2 Lithium-Ion Batteries

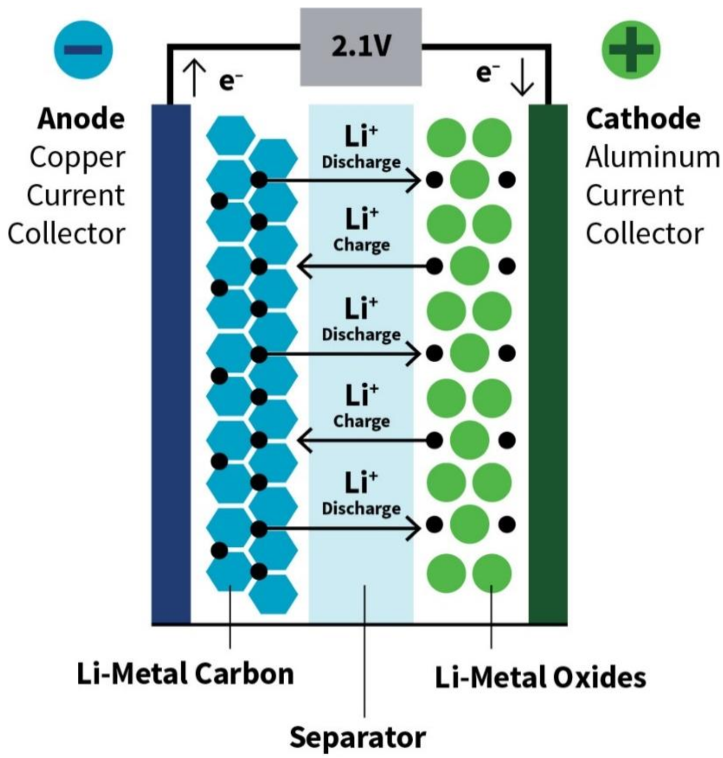

Figure 3-5: Construct of a Lithium Ion Battery, Anode, Cathode, Electrolyte

Lithium-ion batteries (LiBs) are rapidly becoming ubiquitous and are being heavily utilized in energy storage applications. LiBs have superior energy and power densities and a high round-trip efficiency, reducing the footprint required in the design of a system. The main drawbacks of LiBs are their thermal management requirements (cooling and heating requirements to maintain the cells at operational temperatures) when discharging, reduced operating temperature range, and increased risk of thermal runaway relative to other technologies.

A thermal runaway occurs when a battery's internal temperature rises to a level that initiates a self-sustaining reaction. The reaction is very difficult to start once it has started, and the temperature will continue to increase. Eventually it can result in the battery venting, catching fire, or even exploding, which is a safety concern. There are design specifications, standards and certification requirements to address the thermal runaway and fire hazards for lithium-ion BESS (refer to Section 6.6 Codes and Standards).

Due to technological innovations and improved manufacturing capacity, lithium-ion chemistries have experienced a steep price decline over the past few decades. This has allowed for them to accelerate past other chemistries, making them the dominant battery chemistry being utilized. Applications for LiBs range from small portable electronics to electric vehicles, scaling up to multi-megawatt grid-scale energy storage systems. LiBs can be a safety hazard if not properly manufactured because they have flammable electrolytes that can lead to explosions and fires when damaged or improperly used. Selection of reputable battery manufacturers is key when purchasing a component containing a LiB. In addition, ensure that the cells, battery modules, and BESS have the appropriate certifications and have passed appropriate safety testing.

Figure 3-6: Global Li-Ion Cell Price Decrease Over Time

There are a variety of different LiBs, each with different properties based on their electrode components. This guide will focus on Lithium Iron Phosphate (LFP) lithium-ion batteries, as they are the safest lithium-ion battery chemistry, while offering a high current rating and long cycle life. It is worth noting that another variant of LiB: Nickel Manganese Cobalt (NMC) is also popular, especially in electric vehicles. However, LFP is the preferred technology as it is comparatively safer, cheaper, and have a longer lifespan.

Table 3-3: Lithium-ion Battery (LFP) Parameters

Parameter	Value
Energy Density (Wh/L)	325
Specific Energy (Wh/kg)	90-160
Charge/discharge efficiency	80-90%
Self-discharge rate (per month)	0.35% to 2.5%
Cycle life	2500 - 9000
Nominal cell voltage	3.3
Environmental Operating Temperatures	-20° to 45°C

3.3.3 Comparing Battery Chemistries

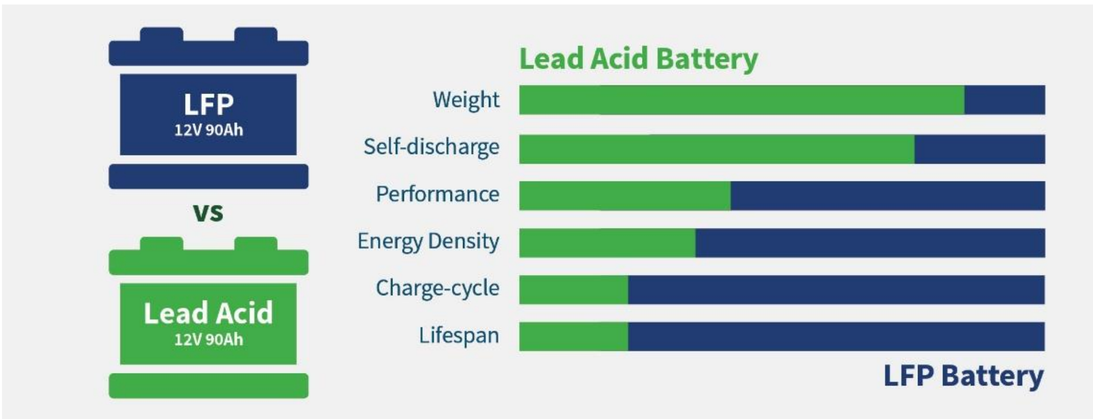

Figure 3-7: Differences between a Li-Ion and Lead Acid Battery

Owing to their high energy densities, and long cycle lives, LiBs have become the primary chemistry for most BESS installations. They have surpassed lead acid batteries in nearly every metric, and their costs have experienced steep price declines due to technological innovations and improved manufacturing capacity.

Table 3-4: Comparison of Battery Chemistries

Attribute	Lead Acid Battery	Lithium Ion Battery
Performance	Lower energy density, 30-50 Wh/kg	Higher energy density, 150-200 Wh/kg
Cost	Lower upfront cost, higher maintenance	Higher upfront cost, lower maintenance
Lifespan	300-500 cycles	500-1,500 cycles
Self-discharge rate (per month)	3% to 20%	0.35% to 2.5%
Environmental Considerations	Contains toxic lead and highly acidic electrolyte components	No toxic heavy metals
Weight and Size	Heavier, takes up a larger volume	Lighter, more compact

4. BESS Use Cases

Battery storage is an essential enabler of the energy transition, and behind-the-meter battery storage is a crucial part of it. Many new and crucial technologies are being adopted that utilize electricity, including the advancement of electric vehicles, heat pumps for heating and cooling, and a multitude of “smart” devices. This is increasing the demand from each building, and the population continues to increase along with it, amplifying demand requirements. BC Hydro recognizes the needs of the energy market, and those needs align with its mandate and goals to ensure the supply of sufficient grid capacity to meet future needs. BC Hydro has introduced programs to assist with enabling the energy transition and aid customers with the reduction of energy prices, decreasing blackout risk, and decreasing greenhouse gas emissions.

Incorporating behind-the-meter BESS solutions can provide the following benefits to customers:

Figure 4-1: C&I BESS Use Cases

- Resiliency/Reliability:
  - Backup Power During Power Outage.
  - Power Quality (Voltage and Frequency).
  - Power Factor Correction.
- Demand Management:
  - Peak Shaving.
  - Load Limiting/Shaping and Reduced On-Peak Costs
  - Manage Billing Impacts.
- Supporting Electrification:
  - Replacement and Optimization of Diesel Generators for Backup Power.

BESS can help customers increase reliance, manage outage impacts, take advantage of time-based energy pricing and can help utilities with capacity savings, localised grid management benefits, and infrastructure planning.

Note: A customer could design a BESS to meet one or multiple of these use cases, depending on their needs.

4.1 Resiliency/Reliability

4.1.1 Backup Power During Power Outage

A BESS can provide backup power during times of power outages or other emergencies. This can help keep critical equipment functioning during unexpected events. Battery Energy Storage Systems can be designed to support the entire facility and provide sufficient backup power to maintain normal energy consumption levels, but this comes at a higher cost to meet the entire load. Hence, most systems are designed to provide partial backup power for critical loads like refrigerators, server, internet, and lighting.

A user should consider the trade-off between back up needs and system costs while planning their BESS for power backup.

4.1.2 Power Quality (Voltage and Frequency)

Variations in both generation and demand on the grid will cause the voltage and frequency to deviate from the target value. Small deviations can be absorbed by the system; however, some industrial equipment can be particularly sensitive to variations in voltage or frequency, leading to performance or production issues at the facility, or even damage to the equipment. The fluctuations do not have to be large to cause an instability in the system, and with the penetration of renewable generation systems increasing, the frequency of these fluctuations is increasing as well. A BESS can aid in managing these variations, improving the overall grid stability and power quality, smoothing the load on the grid and restoring equilibrium in real-time. The inclusion of BESS can reduce the usage of conventional generators for these activities, no longer requiring them to ramp up and down. Quickly ramping up and down conventional generators can cause significant wear and tear, leading to higher maintenance costs and reduced efficiency.

The source of frequency and voltage fluctuations can originate within a facility or behind-the-meter due to certain equipment operating profiles. BESS can often be used to mitigate these internal power quality issues.

The BESS can be configured to provide the following services:

- Frequency Response/Support requires the BESS to respond to deviations in frequency and balancing momentary demand and supply fluctuations.
- Voltage Regulation uses the BESS to control reactive power to maintaining voltage levels within specified limits. BESS can provide reactive power management necessary to offset the effects of inductive and capacitive loads, ensuring stable and reliable grid operation. Voltage regulation is driven by the PCS’s capabilities and thus does not require the BESS to discharge or charge. However, it does require that the PCS is appropriately sized and designed to allow for operation over a range of power factors, while maintaining the necessary real power output.

Power quality applications for batteries are typically unique and specific to a C&I installation requiring power system studies to be completed.

4.1.3 Power Factor Correction

A high-power factor is generally desirable in a power delivery system to reduce losses and improve voltage regulation at the load. Individual electrical customers can be charged by the utility for low power factors. To correct the low power factor and remove the fees, the customer can install correction equipment to increase their power factor. Compensating elements near an electrical load will reduce the apparent power demand on the supply system. Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying or absorbing reactive power. This can be achieved by adding capacitors or inductors that act to cancel the inductive or capacitive effects of the load, respectively. BESS units have the capability of offsetting both the capacitive and inductive effects of local loads and can be installed on-site local to the facility.

4.2 Demand Management

4.2.1 Peak Shaving

BESS play a crucial role in managing and reducing peak demand charges for C&I facilities. Peak demand charges are typically based on the highest level of power consumption during a billing period, which can significantly impact electricity costs. Peak shaving is a reduction of the energy consumed during the peak demand on the electric grid. Energy consumers reduce their energy demand from the electric grid throughout the peak periods. This can be achieved by simply scaling down on power usage, or by using stored energy from a BESS.

BESS can help mitigate peak demand charges through the following mechanisms:

- Peak Shaving: BESS can discharge stored energy during periods of high demand, effectively reducing the peak load on the grid. By lowering the peak demand, facilities can avoid the highest demand charges imposed by utilities.
- Demand Response Participation: BESS can enable C&I facilities to participate in demand response programs, where they are compensated for reducing their load during peak times or grid stress events. This can provide additional revenue streams and further offset peak demand charges. BC Hydro has the “Demand Response for Businesses” program (see Section 10.1 for more details).
- Enhanced Energy Management: By integrating BESS with energy management systems, facilities can optimize their energy usage patterns, ensuring that energy is used more efficiently, and peak demand is minimized.

Overall, incorporating BESS into C&I applications can lead to substantial cost savings, improved energy efficiency, and enhanced grid stability.

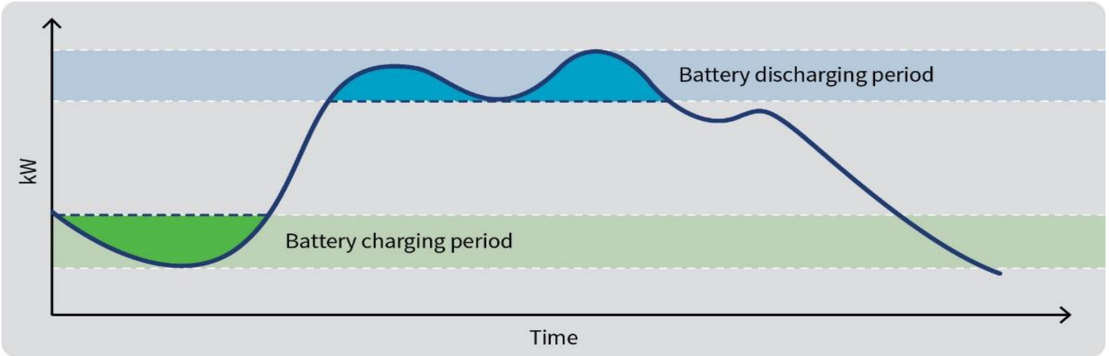

Figure 4-2: Peak Shaving Concept

4.2.2 Load Limiting/Shaping and Reduced On-Peak Costs

Load limiting, or shaping, involves managing and controlling the power consumption patterns of a facility to optimize energy usage. The process involves shifting demand away from peak hours to off-peak hours. A customer would utilize the stored energy from an onsite BESS during peak hours and then proceed to charge the unit during off peak hours, without any changes to the consumer load profile. This can achieve the following benefits for the customer:

- Optimized Energy Usage: By smoothing out peaks and valleys in energy consumption, load shaping helps maintain a more consistent and efficient energy usage profile.
- Cost Savings: Reducing peak demand charges and shifting energy usage to off-peak times can significantly lower electricity bills.

In addition, customers using load limiting practices can result in benefits for the utility, such as:

- Enhanced Grid Stability: By managing load more effectively, customers can contribute to overall grid stability, reducing the risk of blackouts and improving power quality.
- Increased Equipment Lifespan: Smoothing out power consumption can reduce wear and tear on electrical equipment, leading to longer operational lifespans and lower maintenance costs, which can also be passed on to the customers.

Typically, customers will use load limiting practices to reduce time-of-use tariffs, whereby consumers are incentivized to shift consumption to hours of the day when tariffs are low. BC does not have time-of-use tariffs for C&I customers but offers incentives to customers. There are two programs, the Energy Storage Incentives (ESI) program (see Section 10.4.2 for more details) and “Demand Response for Businesses” program (see Section 10.1 for more details). The ESI program, specifically, gives BC Hydro the ability to dispatch the BESS in response to changing conditions on the grid. These dispatch signals trigger the battery to discharge, powering the facility it's attached to and reducing demand on the grid. The battery will then recharge later in the day or at night, when demand is lower.

4.2.3 *Manage Billing Impacts*

BESS can be combined with an energy generation technology (typically solar panels installed on site), to store excess energy generated and lower electricity bills. While there may be high upfront costs, adding batteries can reduce reliance on the grid and lower utility bills in the long run. When combined with solar generation, battery storage allows an owner any excess solar energy generation for later use. Less electricity from the grid is used providing long-term savings. In addition, Owners can join programs to feed excess electricity back to the grid in exchange for a generation credit towards future electricity use. BC Hydro offers customers the ability to earn generation credits to offset future electricity use by feeding excess electricity generated into the grid. See Section 10.3 for more information on the Self Generation program. Renewables Integration and Environmental Impacts.

BESS can be combined with an energy generation technology (typically solar panels installed on site), to store excess energy generated and lower electricity bills. Solar and wind power are variable renewable energy sources. They cannot provide constant energy output throughout the day. This can lead to temporal mismatches between renewable energy supply and electricity demand. When production exceeds demand, these generation sources are curtailed to reduce supply into the grid, resulting in lost energy generation. At times of low generation (calm day for wind, nighttime for solar), these sources cannot supply sufficient energy, and the demand will exceed the available supply. To compensate, other generators would have to provide energy to account for this shortfall.

The variability of renewable energy creates an opportunity for batteries. They can absorb the excess energy generated throughout the day to reduce the energy curtailment. The stored energy can then be discharged when it is needed (during periods of high demand or low generation). Increasing the use of renewable energy and combining with BESS to reduce supply and demand imbalances will reduce reliance on fossil fuels and decrease greenhouse gas emissions. This will result greater renewables penetration.

Adopting these technologies increases energy independence by allowing businesses to generate and store their own power. This reduces the reliance on the traditional power grid system, provides greater control over energy costs, and provides opportunities to reduce long-term energy costs.

4.3 Supporting Electrification

4.3.1 *Replacement and Optimization of Diesel Generators for Backup Power*

For C&I facilities, they may have on-site backup generators to provide power for key pieces of equipment during a blackout. Backup generators, typically powered by diesel or natural gas, produce substantial amounts of carbon dioxide (CO_2) and other pollutants during operation. BESS offers a significant environmental advantage over traditional backup generators, particularly in reducing greenhouse gas emissions. BESS can rapidly respond to grid disturbances, ensuring minimal equipment interruption in the facility, while not producing any emissions. If sized correctly, a BESS can provide sufficient backup power to fully replace a diesel generator.

In cases where a BESS cannot fully replace the backup generator, both a BESS and diesel generator can be paired together at a facility. The BESS can provide power initially and allow time for the diesel generator to warm up to an efficient running point. Once the system switches to the diesel generator, any excess power required to run the generator at a more efficient setpoint can be utilized to charge the BESS, reducing the amount of fuel being wasted by running at a less efficient setpoint.

Beyond the direct benefits of using a BESS to reduce GHG emissions at the facility, there are additional indirect benefits, including:

- Reduced Fuel Dependence: Unlike generators that require a continuous supply of fossil fuels, BESS rely on stored electrical energy, eliminating or reducing the need for fuel transportation and storage, will have an impact on GHG emissions.
- Lower Maintenance and Operating Costs: BESS have fewer moving parts and require less maintenance compared to generators. This reduces the environmental impact associated with the production, transportation, and disposal of maintenance-related materials.

By transitioning to BESS for backup power, C&I facilities can significantly reduce their GHG emissions, contributing to a more sustainable and environmentally friendly operation.

5. Selecting a Contractor

Figure 5-1: Qualified Electrical Worker

The most crucial initial step when considering the installation of a Battery Energy Storage System (BESS) in the business is to select a qualified contractor with knowledge of BESS development projects. This is essential because batteries require proper setup and programming tailored to each customer's specific circumstances, including their location, energy requirements, and personal preferences. A contractor will collaborate with the owner to understand the owner’s needs and subsequently select the most suitable battery for the situation.

A qualified contractor typically will perform the following:

- Perform a feasibility study to determine areas where a BESS can optimize energy usage in the facility and decrease costs.
- Design the energy system and manage its installation.
- Optimize the system size based on the electricity use profile.
- Follow all jurisdictional building requirements, including securing permits.
- Assist with the application process for any incentive programs provided by utilities and ensuring that all program parameters are met.
- Provide estimated monthly savings and payback of the project.
- Provide warranty on workmanship and may provide O&M options.

5.1 What Should I Look for When Selecting a Contractor?

The selection process for a qualified BESS installer should involve the following checks:

- What are the certifications that the battery contractor possesses?
  - Ensure the contractor is certified for the specific battery requirements. Suppliers typically offer certification training programs for proper BESS installation. Verify that the contractor and anyone the contractor plans to sub-contract with has completed these programs and that their certifications are current.
- Is the battery contractor listed on the battery manufacturer's website?
  - If a contractor is listed on the battery manufacturer's, it indicates that the contractor has completed the manufacturer's certification program.
- Is the electrical contractor working with the Alliance of Energy Professionals?
  - The Alliance of Energy Professionals is a network of independent lighting, electrical and mechanical professionals. They assist commercial and industrial clients in identifying, investigating, and implementing energy efficiency solutions. BC Hydro can provide a referral to an Alliance contractor to business customers. Complete a Referral Request Form or contact BC Hydro's business help desk at 1 866 522 4713.
- Is the BESS contractor an electrical contractor?
  - Battery contractors must employ qualified electrical contractors, to be able to design the systems and to have the systems installed. Design of the system must be carried out by licensed Professional Engineers, with each specific aspect being properly designed by an Engineer of that specific discipline. For the onsite installation, they must have Master Level Electricians (Red Seal Certified Electrician) as the Field Service Representative.
- Check if the battery contractor is a member of the Canadian Renewable Energy Association (CANREA) website (Directories - Canadian Renewable Energy Association). CANREA works to enhance and promote the welfare of the Canadian wind energy, solar energy, and energy storage industries, and has code of conduct that each member must follow. While it is not mandatory for a contractor to be a member, it will provide the owner assurance in their capabilities.
- Do they have insurance?
  - The contractor should possess sufficient insurance coverage for any potential damages and liabilities during the installation process. Note that the insurance will not cover the battery itself, as that would be covered under the separately under the warranty.
- Are they part of Work Safe BC?
  - Ensure that the contractor is a reputable company under Work Safe BC.
- What are the testimonials on the battery contractor?
  - The owner should request a list of past clients to review completed projects by the contractor, to verify their reputation.

An owner can find a qualified contractor through the Canadian Renewable Energy Association member directory or the BC Sustainable Energy Directory.

5.2 What Should Be Included in a Quote from a Battery Contractor?

At the C&I scale, it is probable, there will be two stages to the project. First a feasibility study will be performed to determine how best a BESS can be utilized at the facility. A quote from a contractor conducting a study should include:

- Feasibility Study Scope of Work.
- Costs to perform study.
- Anticipated timeline for completion.
- Financing options for the study.
- Example report of what the customer will receive at the completion of the study.

Financing options should include what the cash price is for the installation versus the price of any financing options, with associated fees.

Once the study is completed, the contractor, or another qualified contractor, can use the information to properly size the potential system and prepare a quotation for the design and installation of the BESS. Any quote from a contractor should include:

- Equipment specifications.
- Scope of work.
- Write-up on the electrical system proposed.
- Engineering design costs for any civil, electrical, mechanical work and production of drawings.
- Land survey costs.
- Preliminary schedule to complete the work.
- Equipment costs.
- Installation and construction labour costs.
- Financing options for the battery.
- A product warranty.
- Performance warranty.
- And a workmanship warranty.

Financing options should include what the cash price is for the installation versus the price of any financing options, with associated fees. A careful review of the warranties should be done in detail. For instance, the terms and conditions may say that the warranty is for 10 years, but there may be exclusions that might apply to the system and setup.

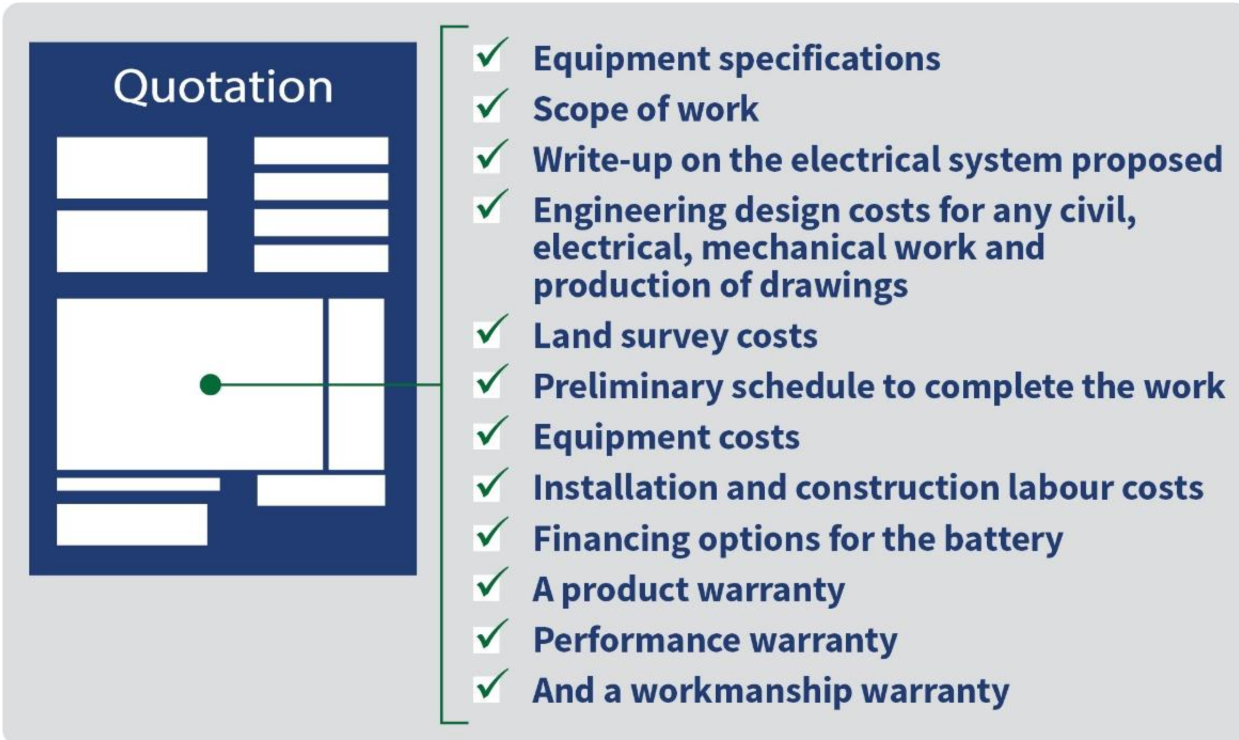

Figure 5-2: Items to be Included in a Quote from a Contractor

6. Selecting a Battery

6.1 Meeting Use Cases

The Owner should thoroughly consider all potential use cases (see Section 4: BESS Use Cases) when selecting a BESS. The first step will be hiring a contractor to perform a feasibility study of the facility. The study will look at yearly load patterns and electricity expenditures to identify areas where a BESS can be utilized to decrease costs for the facility or to ensure certainty of power. The study will aid in determining the expected Use Cases for the BESS. Further discussion with the contractor will help clarify any questions regarding usage. This collaborative process will establish the Owner's expectations from the BESS and how they intend to control the system. The contractor should offer detailed guidance on configuring the system to meet the Owner's specific use cases.

For large industrial facilities, BC Hydro offers reimbursements for a Feasibility Study. Review eligibility at the following link: Energy studies & audits.

6.2 Sizing

The second step in battery selection is to determine the appropriate size of the battery for the use case. Battery energy capacity refers to the amount of energy a battery can store and is typically measured in units of kilowatt-hours (kWh), or megawatt-hours (MWh) for larger systems. The battery energy capacity indicated on the nameplate of a BESS unit represents the total capacity. However, all battery storage systems have a parameter known as the depth-of-discharge (DoD) to limit battery degradation and to meet the anticipated lifespan. The DoD defines the percentage of the total capacity that can be used, and it is less than 100%. For instance, if a 10-kWh battery has a DoD of 80 percent, it will provide 8 kWh of usable energy. When sizing and selecting a BESS, it is crucial to compare batteries based on their usable energy rather than their total capacity. Lithium-ion battery systems typically have a DoD of 80 percent or higher.

The sizing will be derived from a feasibility study of the facility. The Use Cases determined from the study will drive the development of requirements for sizing the system as it will need to meet those load requirements to realize the cost savings. For instance, if the study determines that savings can be obtained by reducing the Peak Demand of a system during the day, the BESS will need to be sized to handle that power capacity and be large enough to provide power for the required duration. The contractor or a qualified installer can then assist the owner in selection of a BESS that meets their use case needs.

The contractor will also need to determine BESS parameters with respect to how long the BESS will be operated for (Useful Life), loss of capacity year-over-year due to degradation (BESS Degradation), and expected load profile. For any of the Use Cases, the contractor will utilize each of these parameters in the BESS sizing calculation to determine the storage capacity of the BESS at initial installation ensuring it can provide sufficient power for the anticipated BESS lifespan.

6.2.1 BESS Sizing for Backup Power Outages

To size a BESS for providing backup power, a contractor can perform the following procedures:

- Work with the owner to determine the average power consumption (in kWh) of the critical loads for a given period (ideally a year). The feasibility study should yield information for each piece of equipment. It is also advantageous to consider consumption required in the future and forecast additional potential critical loads.
- Determine for how long the BESS will need to provide power (expressed in hours). This can be determined by viewing past data from the previous year to look at the average outages.
- Calculate the total load (in kWh) based on the critical loads' power consumption total and the period required to maintain that load.
- Select the system size that can power the total load, while considering the sizing limits provided by the codes and standards for BESS (see Section 6.6) and ensure the sizing considerations for other Use Cases are included in the sizing requirements of the BESS.

6.2.2 BESS Sizing for Power Quality

BESS sizing for frequency and voltage response is relevant for C&I applications, particularly installations with large pieces of equipment. The factors to consider for the sizing include:

- The grid stability requirements.
- Acceptable frequency deviations.
- Renewable energy penetration in the facility (if any).

This sizing is conducted using a power system study, which simulates various grid events, the impact to the connected loads at the facility, and models the rapid BESS response. Since frequency deviation events are typically brief (lasting under a few seconds), the BESS discharge duration can be relatively short.

The Power Conversion System (PCS) sizing is crucial for voltage regulation. A PCS which can operate over a range of both leading and lagging power factors is necessary to provide voltage regulation. Furthermore, it should have sufficient apparent power (MVA) to provide the necessary real and reactive power at the same time.

Procurement of a BESS to satisfy the power quality use case for a facility requires comprehensive modeling and analysis to ensure proper sizing of the system and will only be useful to support larger pieces of equipment. Owners should inquire whether the contractor can perform these analyses and about the associated costs.

6.2.3 *BESS Sizing for Power Factor Correction*

Sizing a BESS to perform power factor correction for a facility will also rely heavily on the PCS sizing. The PCS sizing is crucial and requires that it can operate over a range of both leading and lagging power factors. In addition, it should have sufficient apparent power (MVA) to provide the necessary real and reactive power. These values will be obtained from a study of the facility loads to determine the shortfall reactive power that the BESS will need to supply when required.

6.2.4 *BESS Sizing for Peak Shaving/Peak Demand Reduction*

Sizing a BESS for peak shaving involves determining the optimum size of the BESS to reduce load peaks during peak shaving periods. A facility will need to look at its annual peak demand for electricity consumption to determine if there are points where the facility has had fluctuations pushing it into a higher Demand Charge tariff. The BESS discharges at the rate necessary to lower the peak demand to below the peak demand threshold for that period. During off-peak hours the BESS charges at a lower rate. BC Hydro's Business Service Rates operate on the following rate schemes: Small General Service Rate, Medium General Service Rate, and Large General Service Rate. The Medium General Service Rate and Large General Service Rate contain Demand Charges that are billed to customers based on the rates at which they use electricity. Table 6-1 details the Service Rates for Business Customers.

Table 6-1: Service Rates for Business Customers

Service Rate	Service Rate Requirements	Demand Charge
Small General Service Rate	An annual peak demand less than 35 kW.	$0.00 per-kW.
Medium General Service Rate	An annual peak demand between 35 and 150 kW, and that use less than 550,000 kWh of electricity per year.	$6.03 per-kW.
Large General Service Rate	An annual peak demand of at least 150 kW, or that use more than 550,000 kWh of electricity per year.	$13.75 per-kW.

A customer will need to find out when the peak demand periods occur, for how long, and what the annual peak demand for the facility is. The BESS can be sized based on these parameters.

6.2.5 *BESS Sizing for Load Limiting/Shaping*

The requirements to be able to engage in Load Limiting/Shaping are driven by the Energy Storage Incentives Program and Demand Response for Businesses Program. To size a BESS for providing Load Limiting/Shaping, a contractor can perform the following procedures:

- Work with the owner to determine the power consumption (in kWh) of the critical loads for a given period (ideally a year). The feasibility study should yield information for each piece of equipment. It is also advantageous to consider consumption required in the future and forecast additional potential critical loads.
- Determine for how long the BESS will need to provide power (expressed in hours). Per the incentive programs offered by BC Hydro, the current duration is 4 hours, however, the

BESS should be sized to cover additional time to ensure the incentive requirements are met and to account for degradation over system life.

- Calculate the total load (in kWh) based on the critical loads' power consumption total and the period required to maintain that load, along with the necessary contingency factors.
- Select the system size that can power the total load, while considering the sizing limits provided by the codes and standards for BESS (see Section 6.6) and ensure the sizing considerations for other Use Cases are included in the sizing requirements of the BESS.

6.3 Chemistry

When looking for a choice among battery suppliers of a particular chemistry, contractors should be selecting systems with a high degree of safety, high energy densities, and long lifetimes. Previously, lead-acid was the chemistry of choice to use, but it suffers from low energy density, poor environmental impact, and high self-discharge. The lead-acid energy storage systems could not be scaled up without taking up entire rooms or areas to meet the energy capacities required.

At this moment in time, in terms of lithium-ion batteries, the Lithium Iron Phosphate (LFP) chemistry is widely considered as the best commercialized option for stationary storage applications. LFP does not excel at any particular performance category, but it is a robust chemistry with competitive energy density and degradation. LFP is the current market leader for stationary batteries and presents several advantages such as lower per unit electricity cost and little use of cobalt and nickel. The use of iron instead of higher priced materials like cobalt and nickel allows for it to compete on pricing and have a high safety performance. LFP is also proven to have a much safer than other lithium-ion battery chemistries having a higher thermal runaway temperature.

6.4 Energy Management System

An approved EMS and BMS shall be provided with the system. The EMS and BMS should monitor operation conditions and maintain voltages, currents, and temperatures within the supplier's specifications. Per NFPA 855, the EMS shall electrically isolate the BESS, or the affected components of the system, or place the system in a safe condition state if potentially hazardous conditions exist. The EMS shall prompt the owner with the potentially hazardous condition. It is good practice for the contractor, or the qualified installer, to demonstrate this functionality, safely, with the owner so they can understand the prompt of the issue. Typically, the EMS and BMS are provided by the same vendor as the core battery system.

6.5 Enclosure

NFPA 855 states that the BESS enclosure should be constructed of non-combustible materials and should be marked with the appropriate environmental rating based on the type of exposure required to be met. The contractor should ensure that the BESS unit being utilized has an enclosure that will meet the requirements of the selected location.

6.6 Codes and Standards

Every product has region-specific codes and standards that it must comply with. Similarly, BESS are designed and built to a number of codes and standards, and their installation requires additional standards to be followed to ensure it is installed safely and correctly.

Note that a standard defines specifications, while a code is a standard that has been adopted by a governing authority and becomes the requirements that must be adhered to.

6.6.1 Standards

The product standards used in the battery industry may cover specific components, full battery systems, or the entire BESS installation. It is the responsibility of the owner and the certified contractor to make sure the chosen BESS respect at least the following standards:

- UL Certifications:
  - UL 1741, Power Conversion Systems (Inverters).
  - UL 9540, Energy Storage System and Equipment.
  - UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation.
  - UL 1973, Batteries in Stationary Applications.
  - UL 1642, Lithium-Ion Batteries.
- CSA: CSA C22.2 No 107.1, Power Conversion Equipment.
- Enclosure rating (example NEMA Type 3R).

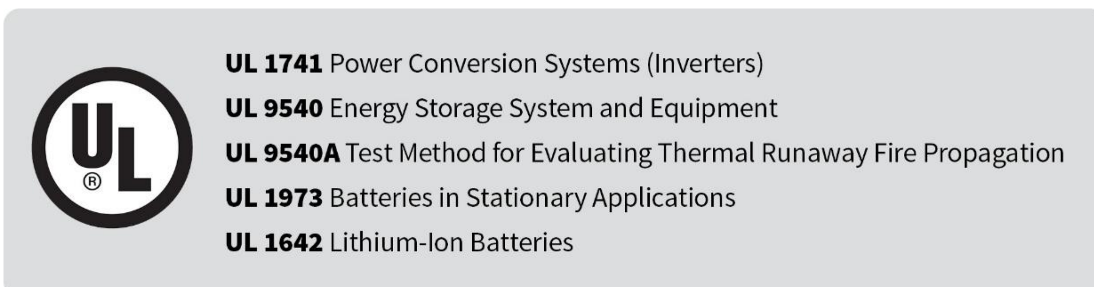

Figure 6-1: UL Standards for BESS

Note: Some BESS models might not include certain equipment integrated with it (e.g. a PCS) and therefore won't list the related certifications for the missing component. It is crucial for the contractor to know which certifications are required for the batteries and any additional equipment.

Conforming to the above standards enables safe installation and operation of the BESS during normal operating conditions in the building. While it's possible to buy BESS components separately and build a system with the right knowledge and experience, such a system would not be fully certified to the necessary standards and would pose unknown risks to the owner and the public at large. Such a system would not be approved by any inspecting body or jurisdiction, and if such a system was installed and energized, it could result in serious consequences for the owner of the equipment such as investigations, fines, attention from law enforcement agencies, insurance issues, and civil liabilities for property damage or personal injury. It is imperative that only properly certified equipment be installed and is properly inspected.

It is possible for an owner or contractor of a system, created from individual components, to have the necessary certification testing performed, but it would be economically infeasible. The best course of action is to purchase an off-the-shelf system that is certified and tested to all the appropriate standards and will contain all the required protections and controls.

In addition to the certifications listed above, a comprehensive list of standards relevant for BESS or its components is provided in Appendix A, Certifications for BESS.

6.6.2 Codes

All equipment to be installed shall comply with all applicable provincial regulations and local codes for the federal, provincial, and local jurisdictions. All equipment supplied shall comply with applicable building, mechanical, fire, seismic, structural and electrical codes. These codes include, but are not limited to, the:

- BC Electrical Code, which follows the Canadian Electrical Code (CEC).
- BC Plumbing Code, which follows the National Plumbing code.
- BC Fire Code, which follows the National Fire Code.
- National Building Code of Canada (NBCC).
- National Energy Code of Canada for Buildings (NEBC).
- National Fire Protection Association (NFPA). This includes:
    - NFPA 68 standard on Explosion Protection by Deflagration Venting.
    - NFPA 69 standard on Explosion Prevention Systems.
    - NFPA 72 standard on National Fire Alarm and Signaling Code®.
    - NFPA 855 standard for the Installation of Stationary Energy Storage Systems.

6.7 Available Battery Suppliers/Retailers

BC Hydro does not endorse any supplier in this guide. However, for reference purposes, a list of commonly used commercially available off the shelf BESS products for small commercial applications can be found at Energy storage battery list (bchydro.com).

Note that the reference is not meant to be an exhaustive list and does not include suppliers suited for larger commercial and industrial BESS offerings. The owner should work with the contractor to determine from available suppliers which would be best suited for the project's use cases.

6.8 Permitting

Depending on the size of the project, there are several permits that may be required to build a BESS. Construction of a BESS facility is expected to require several provincial (e.g., environmental, electrical; safety) and municipal (e.g., development and/or zoning) permits. There is a large amount of permitting and compliance work that will need to be performed to ensure the BESS meets all municipal, provincial, and federal requirements. It is important for a contractor to be familiar with the permitting process. To prevent construction delays, it is recommended that the Contractor being the permitting process as soon as possible.

Table 6-2 provides a list of permits that may be required for a BESS project.

Table 6-2: Potential Permits Required for a BESS Project

Permit/ Approval Name	Short Description/ Impact on Project	Issuing Body
Electrical Installation Permits	Both licensed contractors and homeowners installing electrical equipment require electrical installation permits.	Technical Safety BC/Local municipality
Building Permit	Permits help ensure that construction and major renovations comply with local bylaws, the building code and health and safety standards.	Province of British Columbia
Site Disclosure Statement (Provincial)	Used as a screening tool to identify potentially contaminated industrial and commercial sites. A site disclosure statement would be required if the property was previously used for specified industrial or commercial purposes as per the Contaminated Sites Regulation.	Ministry of Environment and Climate Change Strategy
Short-Term Water Use Approval (Provincial)	Authorizes application to divert and use surface water from a stream, groundwater from an aquifer (often required during construction), for a term not exceeding 24 months.	Ministry of Water, Land and Natural Resource Stewardship
Heritage Inspection Permit (Provincial)	Required for an Archeological Impact Assessment (AIA), which determines the presence of archeological sites which warrant protection or are already protected under the *Heritage Conservation Act*.	Ministry of Water, Land and Natural Resource Stewardship (Archeology Branch)
Site Alteration Permit (Provincial)	Authorizes the removal of residual archeological deposits once archeological investigations/inspections are completed. Only required if an archeological site is present.	Ministry of Water, Land and Natural Resource Stewardship (Archeology Branch)
Development Permit (Municipal)	Often required by municipal governments; permit process typically includes a report detailing the construction or a building or structure and land along with environmental details/risk	Relevant Municipality

Although the BESS projects described in this guide may not be large enough to require all the permits described in Table 6-2, it is recommended practice that the owner engage with a qualified contractor familiar with the permitting process. This will ensure a smooth project construction development.

6.9 Location and Land Survey

Large BESS installations in the megawatt-hour range require a larger footprint. For instance, there are battery containers that are currently being developed in the 5 MWh range that take up an entire 20-foot shipping container. In addition, the other PCS for a system of this size would have a sizeable footprint for it as well. One of these battery containers will weigh approximately 50 tons. Thus, after initial selection of an area that has a proper separation from buildings, egress routes, and can fit the footprint of all necessary equipment, most developers will contract to have an initial survey performed before any preliminary design work is done. The survey will assess the site at a high level and will, typically, consider the following:

- Precise boundaries and lines of possession.
- Any existing buildings or structures on the property.
- Any easements or water features.
- All power, gas, sewer, and water lines or other utilities on the property.
- Rights of way and access to public or private roads.
- Optionally, the survey may also include wetland easements, site topography, parking, zoning, and flood zone classification.

The information provided by the survey will aid in positioning the BESS correctly on the site and provide a picture of the constraints and risks associated with the site as well.

In addition to the site survey, a series of studies may have to be commissioned to ensure the site placement will be a stable area to place components of this weight or to construct other structures. The following studies may be commissioned:

- Geotechnical Studies:
    - Soil and geological conditions analysis of a site to determine construction suitability.
- Hydrology Studies:
    - Water flow patterns and potential flood risk zones at the proposed site.

6.10 Site Panel Impacts

The BESS is charged from the grid through a connection with the building's electrical panel. This connection is behind-the-meter and will provide the power from the grid to the BESS for charging and auxiliary loads. The contractor will verify if sufficient space is available in the panel to accommodate the BESS with respect to both physical space and power availability. If the electrical panel cannot accommodate the addition of the BESS, the site panel will need to be upgraded to a higher power service. building owners to incorporate additional systems to further electrify the building space, including the incorporation of solar panels, heat pumps, and electric heating (to replace natural gas).

6.11 Distributed Energy Resource Management System (DERMS) Connectivity

If the owner plans to participate in the different demand response programs provided by BC Hydro, the BESS will need to be able to connect to BC Hydro's Distributed Energy Resource Management System (DERMS) to allow BC Hydro to manage the BESS during Demand Response events. This connection must be highly reliable in nature to meet the reliability requirements for the program. The ESS must be capable of receiving commands from BC Hydro through an IEEE 2030.5 certified connection, SCADA, existing API to the DERMS, or other method BC Hydro deems acceptable. Work with the installer to ensure that the selected BESS will be able to meet BC Hydro's DERMS requirements (see Section 9 Distributed Energy Resource Management System for additional details).

7. BESS Integration by Housing Type

The following building types, in BC, are considered in this guide:

Table 7-1: Building Type Definitions

Building Type	Definition
Commercial buildings[1]	Commercial property refers to real estate that is used for business purposes, such as office buildings, retail spaces, warehouses, hotels and motels.
Light industrial buildings[2]	Light industrial refers to property used or held for extracting, processing, manufacturing or transporting products, including ancillary storage.

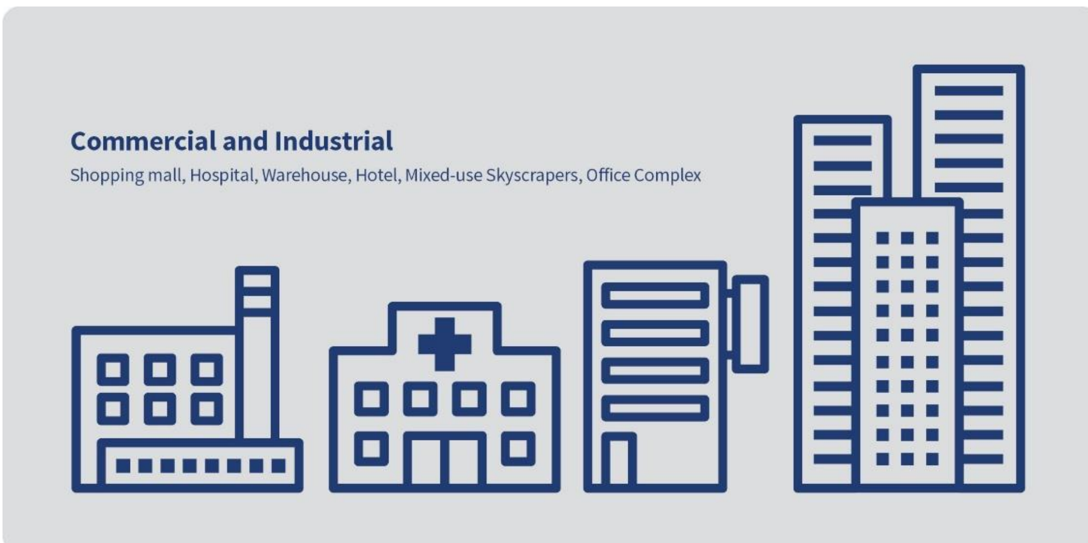

Figure 7-1: C&I building types

For purposes of defining the size of the BESS for the focus of this material, BESS units under 5 MWh in total size will be considered. This is a typical upper limit for BESS used in C&I applications. Larger BESS (>5 MWh) is usually referred to as “utility scale” and involve a separate set of standards and considerations for installation.

Note: All BESS must be approved by BC Hydro before installation to ensure safe and effective operation, even if the battery will not be exporting power to the grid. It is important for BC Hydro's crew and other service providers to know if there is a battery onsite to ensure work can be performed safety.

7.1 Commercial/Light Industrial (C&I) Buildings

Increased BESS unit size requires more selective location and design requirements for the building types listed in this section. Work closely with the contractor to ensure that the systems are properly designed and protected for safe operation.

[1] Understanding property classes and exemptions - BC Assessment
[2] Understanding property classes and exemptions - BC Assessment

7.1.1 Location/Site Selection

Note, an assessment of the space should be done before final selection to ensure that there are no hazards that shall affect the BESS units during its life. Show the potential BESS locations to the contractor, and the contractor's installers, to get their final approval on the selected space. The contractor and the installer should look at how difficult it will be to access the space for installation and ensure that the lifting equipment can get into the space.

In addition, since C&I buildings will have larger BESS capacities they might need to follow utility requirements on the setback distance from critical infrastructure. C&I buildings close to high voltage transmission lines should ensure that their BESS is 60 – 150 m away from the critical infrastructure. The distance is dependent on the size of the transmission line or the substation.

7.1.1.1 Indoor Installations

7.1.1.1.1 BESS Dedicated-Use Buildings

A building can be built on-site to separately store the BESS units, referred to as a BESS Dedicated-Use Building. The building shall be constructed in accordance with local building codes. To be classified as a Dedicated-Use Building, it shall comply with the following:

- The building shall only be used for energy storage, or energy storage in conjunction with energy generation.
- Occupants in the rooms and areas containing BESS shall be limited to personnel that are qualified to operate and maintain the BESS and other energy systems.
- The building shall not have any other occupancy types.

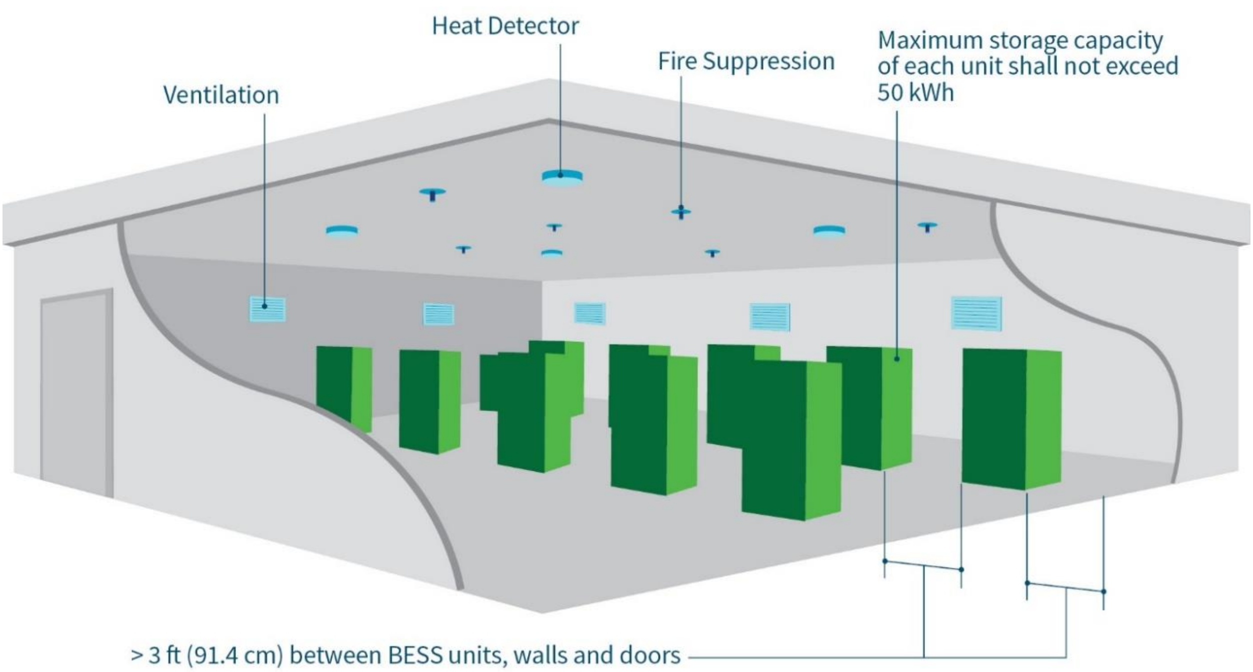

Figure 7-2: Dedicated Use Building BESS Installation Requirements

7.1.1.1.2 Non-Dedicated-Use Buildings

BESS are permitted to be installed inside the building, but this will classify the installation as being installed in a non-dedicated-use building (as the building is used for more than just BESS installation). BESS units shall only be located on the floors that can be accessed by the local fire department laddering capabilities. Technical Safety BC (TSBC) has set this limitation as being 75.5 ft (23 m) above grade. TSBC have stated that a BESS installation shall not be installed below grade. The contractor shall consult with the jurisdictional authority if not under TSBC.

The BESS units are permitted to be placed in the same room as the equipment that they will be supporting, but they must be protected from being accessed by unauthorized personnel. This can be achieved by housing the BESS in a non-combustible, locked cabinet or other enclosure, or locating the system in a separate equipment room accessible only to authorized personnel. BESS units shall not be installed in electrical rooms and shall be accessible to emergency responders without traversing through an electrical room.

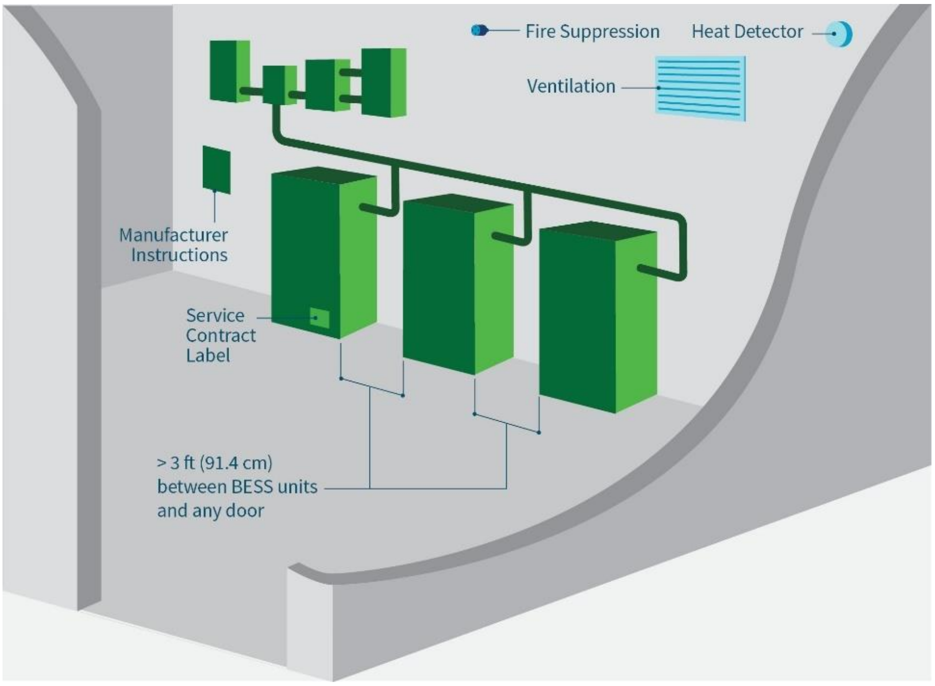

Figure 7-3: BESS Installation Requirements for a Non-Dedicated Use Building

The door of the cabinet or room, in which a BESS is installed shall be labelled with an exterior sign that identifies the manufacturer and model number of the system, the electrical rating (voltage and current) of the contained system, and any relevant electrical, chemical, and fire hazards.

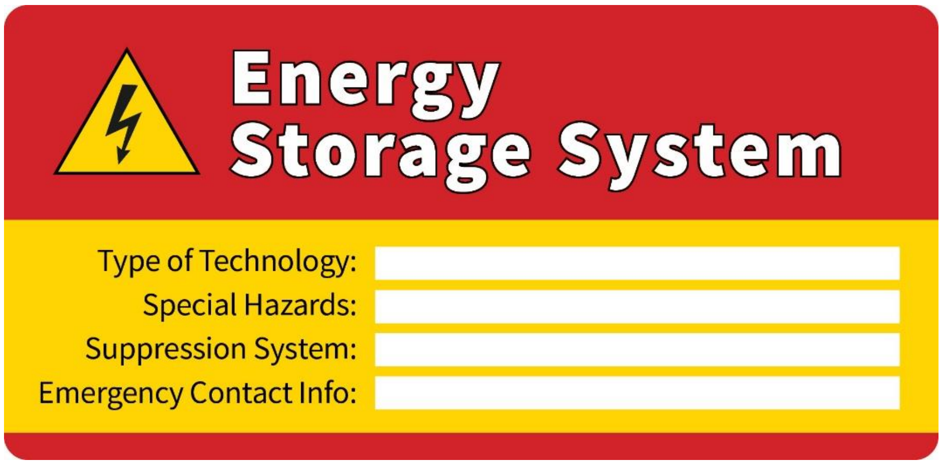

Figure 7-4: Sign for BESS Non-Dedicated Use Building

7.1.1.2 *Outdoor Installations*

For BESS installations that are located outdoors, the units shall be properly rated for outdoor installation and the installation area shall be properly secured. As the energy within the BESS units increases, the energy release from an arc flash event becomes more dangerous, and the danger area increases. To protect individuals from BESS installations shall be secured against unauthorized entry. This can be achieved with a properly constructed security barrier or fence. The barriers need to be constructed with a sufficient separation distance to allow for maintenance and to protect from potential energy releases. Work with the contractor to ensure proper distancing per supplier requirements.

As specified in NFPA 855, BESS located outdoors shall be separated by a minimum of 10 ft (3.0 m) from the following exposures:

- Lot lines.
- Public ways.
- Buildings.
- Stored combustible materials.
- Hazardous materials.
- High-piled stock.
- Other exposure hazards.

Clearances to these exposures can be reduced to 3 ft (91.4 cm), per NFPA 855, only in the following cases:

- When a 1-hour freestanding fire barrier suitable for exterior use and extending 5 ft (1.5 m) above and 5 ft (1.5 m) beyond the physical boundary of the BESS installation is provided to protect the exposure.
- When a building is constructed of exterior walls that are non-combustible, with no openings or combustible overhangs on the wall adjacent to the BESS and the fire resistance rating of the exterior wall is a minimum of 2-hour fire resistance.
- For a building, based on large-scale fire testing of the BESS complying with UL9540A.
- Clearances to exposures other than buildings where fire and explosion testing, to UL9540A, demonstrates that a fire will not generate radiant heat flux sufficient to ignite stored materials or otherwise threaten the exposure.
- When the enclosure of the BESS has a 2-hour fire resistance rating (in accordance with ASTM E119 or UL 263).

BESS located outdoors shall be separated from any means of egress, by no less of a distance than 10 ft (3 m), to ensure safe egress under fire conditions. In addition, exhaust outlets from a BESS shall not be directed onto means of egress, walkways, or pedestrian or vehicular travel paths.

Combustible vegetation and other combustible growth shall be cleared all around an outdoor BESS in a 10 ft (3 m) radius. Single specimens of vegetation are permitted provided they do not form a means of readily transmitting fire. This includes trees, shrubbery, or cultivated ground cover such as green grass, ivy, or succulents.

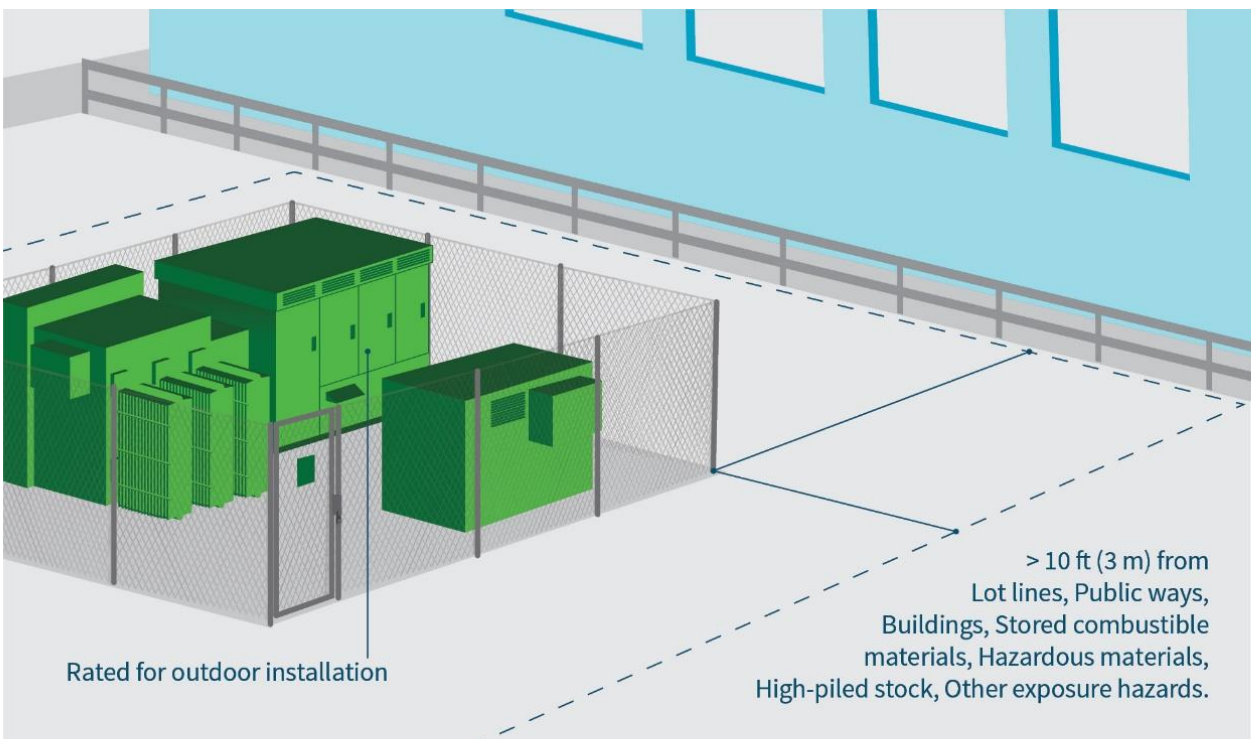

Figure 7-5: An Example BESS System Installed on the Exterior of a Building

In addition to following the requirements listed above, there are three outdoor installation location types that have additional requirements:

- Exterior Wall Installations.
- Rooftop Installations.
- Open Parking Garages.

7.1.1.2.1 Exterior Wall Installations

A BESS can be installed directly on to the exterior wall of a building. The wall of the building must be constructed of materials that are non-combustible with no openings or combustible overhangs provided on the wall adjacent to the BESS. The fire resistance rating of the exterior wall should have a minimum of 2-hour fire resistance. Additional requirements for the design of the system are then required to be able to locate the system directly onto the building (see Section 7.1.2 Design).

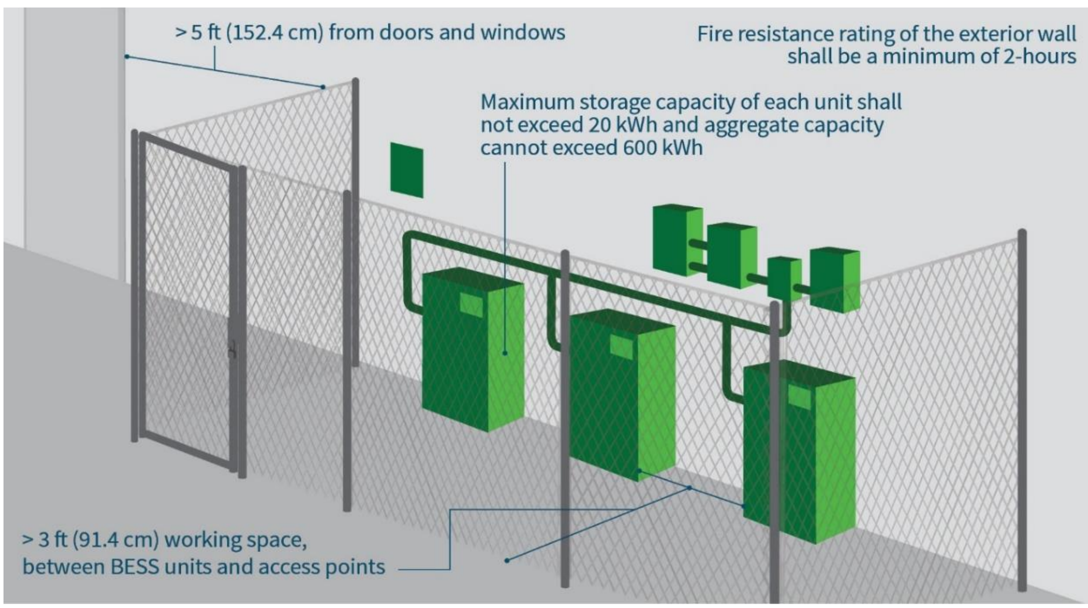

Figure 7-6: Outdoors Wall Installation Example

7.1.1.2.2 Rooftop Installations

BESS has the capability of being installed on the rooftop of buildings. In addition, for the potential for solar panels to be installed on the rooftop, the BESS unit can be installed there as well.

As previously stated, BESS units can only be located on floors that can be access by external fire department laddering capabilities, which includes the roof. TSBC has set this limitation as being 75.5 ft (23 m) above grade. The contractor shall consult with the jurisdictional authority if not under TSBC. NFPA 855, also specifies, that the roofing materials under and within 5 ft

(1.5 m) horizontally from a BESS or associated equipment shall comply with one of the following:

- Be non-combustible.
- Have a class A rating when tested in accordance with ASTM E108 or UL790.

The location of BESS and associated equipment shall be, from the edge of the roof, a distance equal to at least the height of system components but not less than 5 ft (1.5 m) and shall be a minimum of 10 ft (3 m) from the fire service access point on the rooftop.

The remaining requirements for rooftop installation are based on the stored energy within each BESS unit. Table 7-2 describes these requirements as described in NFPA 855.

Table 7-2: Requirements Based on the Energy Capacity of the BESS Unit to be Installed

Greater than 20 kWh/unit	Stairway access to the roof for emergency response and fire department personnel shall be provided either through a bulkhead from the interior of the building or a stairway on the exterior of the building.
	Access, service space, guards and handrails shall be provided where required by the local building and mechanical codes.
	Service walkways at least 5 ft (1.5 m) in width shall be provided for service and emergency personnel from the point of access to the roof of the system.
	A class I standpipe outlet shall be installed at an approved location on the roof level of the building or in the stairway bulkhead at the top level.
	A radiant-energy-sensing fire detection system shall be provided to protect the BESS.
Less than 20 kWh/unit	The systems shall comply with the fire and explosion testing requirements in its intended installation configuration.
	Each BESS unit shall be spaced a minimum of 3 ft (0.9 m) from other units.

Once the design and a general location have been defined for the BESS, additional studies shall be performed to determine if the roof is able to handle the weight of the equipment.

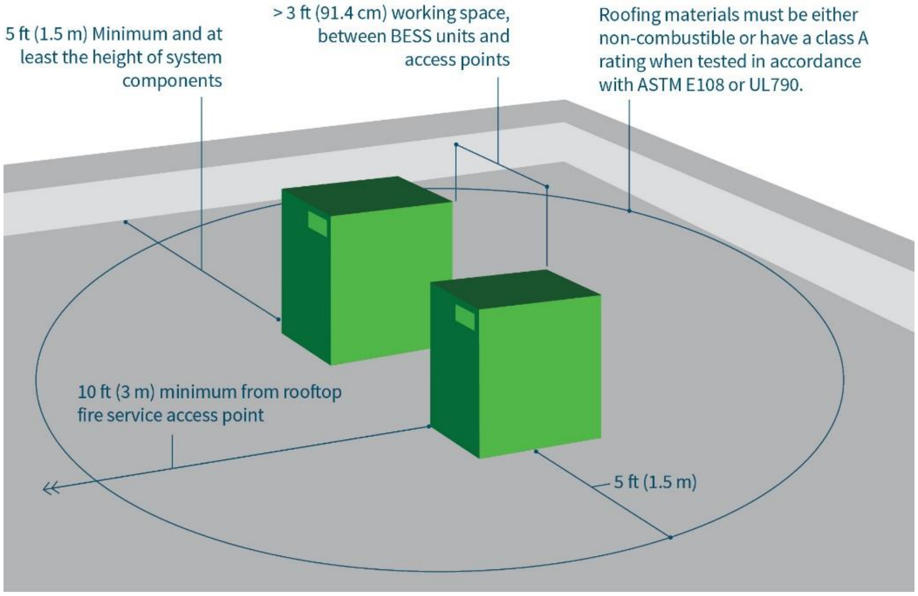

Figure 7-7: Rooftop BESS Installation Example

7.1.1.2.3 Open Parking Garages

If there is an open parking garage onsite (defined as a structure designed for car storage that has openings along at least 40% of the perimeter), BESS can be installed within that structure, per NFPA 855, under the following requirements:

- BESS shall not be located within 50 ft (15.3 m) of air inlets for building HVAC systems.
- BESS shall not be located within 25 ft (7.6 m) of exits leading from the attached building when located on a covered level of the parking structure not directly open to the sky above.
- BESS shall not be located within 10 ft (3 m) of means of egress (an unobstructed path to leave buildings, structures, and spaces).
- A radiant energy-sensing fire detection system shall be installed that is in compliance with all fire codes.
- An approved fence with a locked gate or other approved barrier shall be provided to keep the public at least 5 ft (1.5 m) from the outer enclosure of the BESS.

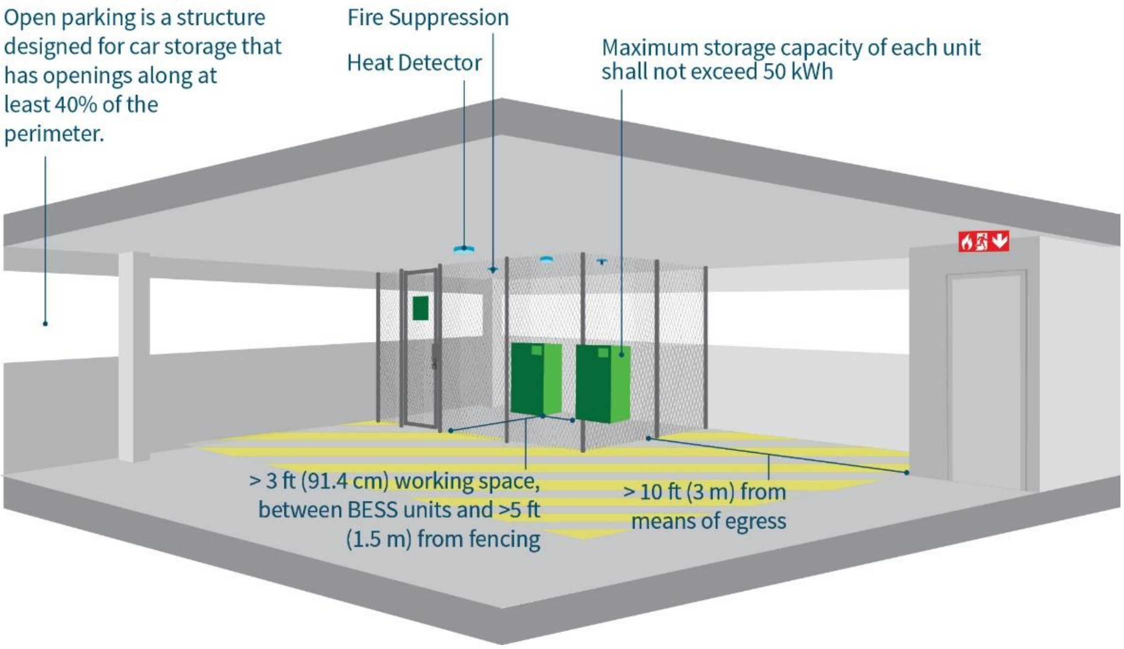

Figure 7-8: Open Parking Garage BESS Installation Example

7.1.1.3 Environmental Exposures

When considering a location for the BESS, whether it be indoors or outdoors, the installation instructions from the supplier shall be reviewed to determine if they have specified any areas where a BESS cannot be located. Typically, it is best practice to ensure that the location of the unit is not at risk of being flooded or placed in an area that has high humidity. The units should not be installed in environments that have a high build-up of dust or block the air ventilation ports of the system. The operating temperatures of the units are generally between -20°C to 50°C and should not be placed in locations where the ambient temperature exceeds the unit's specifications. Verify that the unit can be placed outdoors and will be able to handle precipitation (heavy rain or snow build-up) or salt spray from the ocean.

7.1.2 Design

7.1.2.1 Sizing and Spacing requirements

As specified NFPA 855, for BESS units located in Non-Dedicated-Use buildings and outdoor installations, the design of the BESS should conform to the following requirements:

- The maximum storage capacity of each unit shall not exceed 50 kWh.
- Each unit shall be spaced a minimum 91.4 cm (3 ft) from other groups and from walls (not including the wall the unit may be attached to), doors, and windows:
  - If multiple BESS are installed, the maximum aggregate capacity cannot exceed 600 kWh.
  - In addition to requirements for spacing between units and access points, there shall be a minimum working space surrounding the unit of 91.4 cm (3 ft) or the minimum space defined by the supplier, whichever is larger.

For BESS units installed in Dedicated-Use buildings, there is no maximum stored energy requirement, and the buildings can contain any number of BESS units, provided the spacing requirements are still followed. Also, there are certain conditions in which the requirements can be exceed for BESS unit size and over all storage energy capacity. Refer to Section 7.1.2.2 for these requirements.

A BESS can be installed directly on to the exterior wall of a building. The wall of the building should be constructed of materials that are non-combustible with no openings or combustible overhangs provided on the wall adjacent to the BESS. The fire resistance rating of the exterior wall should have a minimum of 2-hour fire resistance. Per NFPA 855, the design of the BESS on the exterior wall shall then conform to the following requirements:

- The maximum stored energy of each unit shall not exceed 20 kWh.
- If multiple BESS are installed, the maximum aggregate capacity cannot exceed 600 kWh.
- The BESS shall be installed in accordance with the manufacturer's instructions and their listing.
- Individual units shall be separated from each other by at least 3 ft (914 mm).
- The BESS shall be separated from doors, windows, operable openings into buildings, or HVAC inlets by at least 5 ft (1,524 mm).
- In addition to requirements for spacing between units and access points, there shall be a minimum working space surrounding the unit of 91.4 cm (3 ft) or the minimum space defined by the supplier, whichever is larger.

Another special case for BESS units is outdoor walk-in units. Walk-in units are defined as units where a BESS includes an outer enclosure. These units shall only be entered for inspection, maintenance, and repair of energy storage units and ancillary equipment and not be occupied for other purposes, per NFPA 855. The design of the walk-in unit shall comply with the local building code requirements. For the batteries stored within the enclosure, spacing shall not be required between them and the enclosure walls. The maximum size of outdoor walk-in units or BESS cabinets shall not exceed 53 ft x 85 ft 9.5 ft, not including HVAC and other equipment. If a walk-in unit or BESS cabinet exceeds these dimensions, then the installation shall be treated as an indoor installation in a dedicated use building and shall comply with the requirements for said installation type.

7.1.2.2 Hazard Mitigation Analysis (HMA)

The sizing and spacing requirements listed in Section 7.1.2.1 can be modified in certain circumstances. To be able to increase the size of the BESS units or the total BESS energy capacity to a value greater than the sizing requirements specified, a Hazard Mitigation Analysis (HMA) shall be performed.

An HMA investigates all the possible failure mechanisms as well as their consequences for a BESS system. The HMA shall be performed by a qualified specialist and the specialist will need to work directly with the contractor and the supplier to properly conduct the analysis.

During the HMA, as specified in NFPA 855, the following failure modes shall be evaluated:

- Thermal runaway or mechanical failure condition.
- Failure of required protection system such as ventilation, fire detection, fire suppression, leakage gas detection.
- Failure of an energy storage management system or protection system that is not covered be the product listing failure modes and effects analysis (FMEA).

7.1.2.2.1 When an HMA is Required to be Performed

As specified in NFPA 855, the HMA is performed by qualified personnel and is required for cases where:

- New technologies not specifically addressed in the standards are to be installed.
- More than one ESS technology is provided in a single fire area where adverse interaction between the technologies is possible (example BESS and a capacitor).
- Where allowed as a basis for increasing maximum stored energy.
- Where required by the AHJ to address a potential hazard with an ESS installation that is not addressed by existing requirements.
- Where required for existing lithium-ion ESS systems that are not UL9540 listed.
- A HMA shall be required for lithium-ion ESS that exceed 600 kWh for outdoor ESS installations.

7.1.2.2.2 HMAs in Practice

For most applications the HMA is performed as a basis for increasing maximum stored energy (per unit, example wanting to use BESS units with 60 kWh per unit) and when a lithium-ion BESS design exceeds a total of 600 kWh of energy capacity for outdoor ESS installations. The goal of the HMA is to document failure modes of the system and provide the necessary mitigations identified to install with the BESS. The HMA shall be provided to the inspector to inspect and ensure the system will be safe for operation with these increased storage capacities. When an HMA is not required, the BESS installation shall follow the manufacturers and the local regulatory guidelines.

C&I applications will typically need to perform this analysis as they will install much larger systems on-site to support the facility.

7.2 Integration of Safety Systems and Measures

BESS installations should implement the following safety measures:

- Emergency Disconnect Switch:

  All BESS shall include an emergency shutdown function, which will be installed in addition to the main system disconnect switch. The disconnecting means can be a manual switch or can be via a remote control. Each BESS disconnecting means should:

  - Plainly indicate whether it is in the open (off) or closed (on) position.

- Permanently marked “ENERGY STORAGE SYSTEM DISCONNECT”.
- Include the nominal BESS AC voltage and maximum BESS DC voltage.

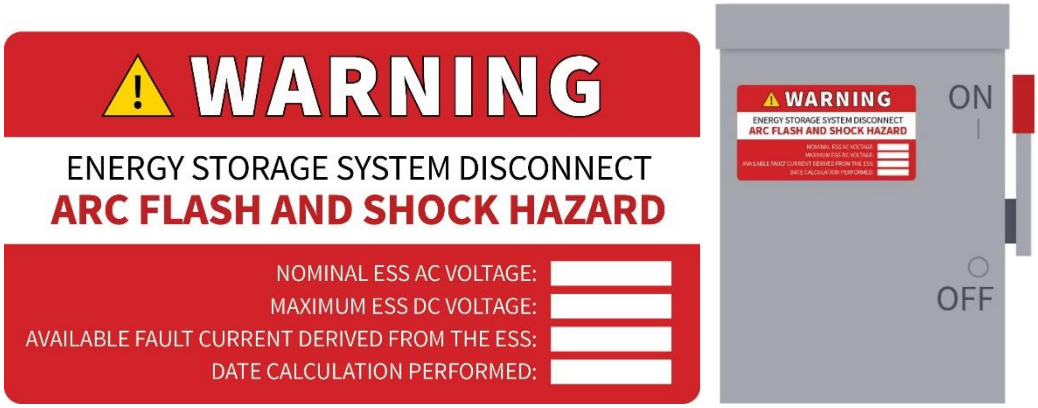

Figure 7-9: BESS Emergency Disconnect Signage

- Signage:

  ANSI Z535 compliant signage should be provided on front doors of rooms or areas with BESS, as well as on the BESS itself. The sign should list the type of technology used (e.g., Lithium ion), any special hazards, the type of fire suppression system installed, and emergency contact information for qualified service and maintenance providers. This label should also be located on the BESS itself. A permanent plaque or directory denoting the location of the disconnecting means for all BESS on or in premises must be installed at each service equipment location.

  The BESS must, also, be labeled with the appropriate UL certifications, and the Power Conversion Systems (PCSs) must be listed and labeled in accordance with UL 1741 or provided as part of UL 9540 listing. Additionally, installed BESS must have a label containing emergency contact information for the qualified service and maintenance providers on the exterior of the installed BESS. These guidelines apply to indoor, outdoor, rooftop, and open parking garage installations.

UL 1741 Power Conversion Systems (Inverters)
UL 9540 Energy Storage System and Equipment
UL 9540A Test Method for Evaluating Thermal Runaway Fire Propagation
UL 1973 Batteries in Stationary Applications
UL 1642 Lithium-Ion Batteries

Figure 7-10: UL Labels on BESS Signage

- Security Barriers:

  BESS installation location should be segregated and secured to prevent access of unauthorized personnel. Indoor installations can achieve this by using locked cabinets and doors. Outdoor installations and installations on rooftop or open parking garage require security barriers, fences, or other permanent enclosures. An approved fence with a locked gate or other barrier must keep the public a minimum 5 ft (1.5 m) from the BESS enclosure. Note that the maintenance distance requirement stated by the manufacturer could be greater than 5 ft.

  Floor mounted BESS units in residences and open park garages may require additional protections in the form of bollards to prevent damage from a vehicle.

  Irrespective of the installation location, it is important that the enclosure mechanism chosen does not inhibit ventilation.

- Safety Data Sheet:

  The safety data sheet (SDS) for hazardous materials contained in the BESS shall be posted within sight of the BESS disconnect switch and the emergency shutdown function.

- Ventilation:

  A BESS should be installed in either a well-ventilated area, or an enclosed space with good ventilation system such that any potential gases and the excess heat generated by the system can be safely diffused away.

- Fire Detection:

  A radiant-energy-sensing fire detection system complying with NFPA 72 shall be provided to protect the BESS.

  Indoor BESS installations in a dedicated or utility room are required to install interconnected fire detection (smoke or heat) alarms. it is good practice to install a smoke alarm in any building or room that a BESS is placed.

  The detection system shall be provided with a secondary power supply, in the chance of a power outage, to supply power to the system for a minimum of 24 hours in operation, or a minimum of 2 hours in alarm.

- Fire Control and Suppression:

  Automatic fire control and suppression systems must be provided for areas within buildings or outdoor walk-in units containing BESS. Sprinkler systems should be installed according to local building and fire codes. For BESS units of 50 kWh or less, sprinkler systems should have a minimum density of 0.3 GPM/ft² (12.2 mm/min) over the area of the room or 2500 ft² (230 m²), whichever is smaller. For larger units, design should be based on fire and explosion testing results. A permanent water source is required for fire control and suppression activities.

  This will be a connection to a public water supply for most sites. Other examples of permanent water sources are water storage tanks and naturally occurring sources, such as rivers, ponds, and lakes. Additional environmental studies may be required if water is to be drawn from natural sources.

- Fire Alarm Control Panel

  A facility will, typically, have the fire alarm systems connected to a centralized fire alarm control panel (FACP) to receive all signals for the facility. The FACP aids emergency personnel in determining the area in which the fire was detected. The fire detection system installed for the BESS shall also be tied into this system. If a FACP does not exist already at the facility, it is recommended to have a system installed along with the BESS unit. Some BESS units may have a FACP installed with the system. All required annunciation means shall be located in a way to ensure efficient response to an emergency, as determined by the AHJ.

- Emergency evacuation route (Means of egress):

  BESS installations shall have a means of egress built in accordance with the building code. Egress doors should open in the direction of exit and be equipped with emergency lighting and panic hardware.

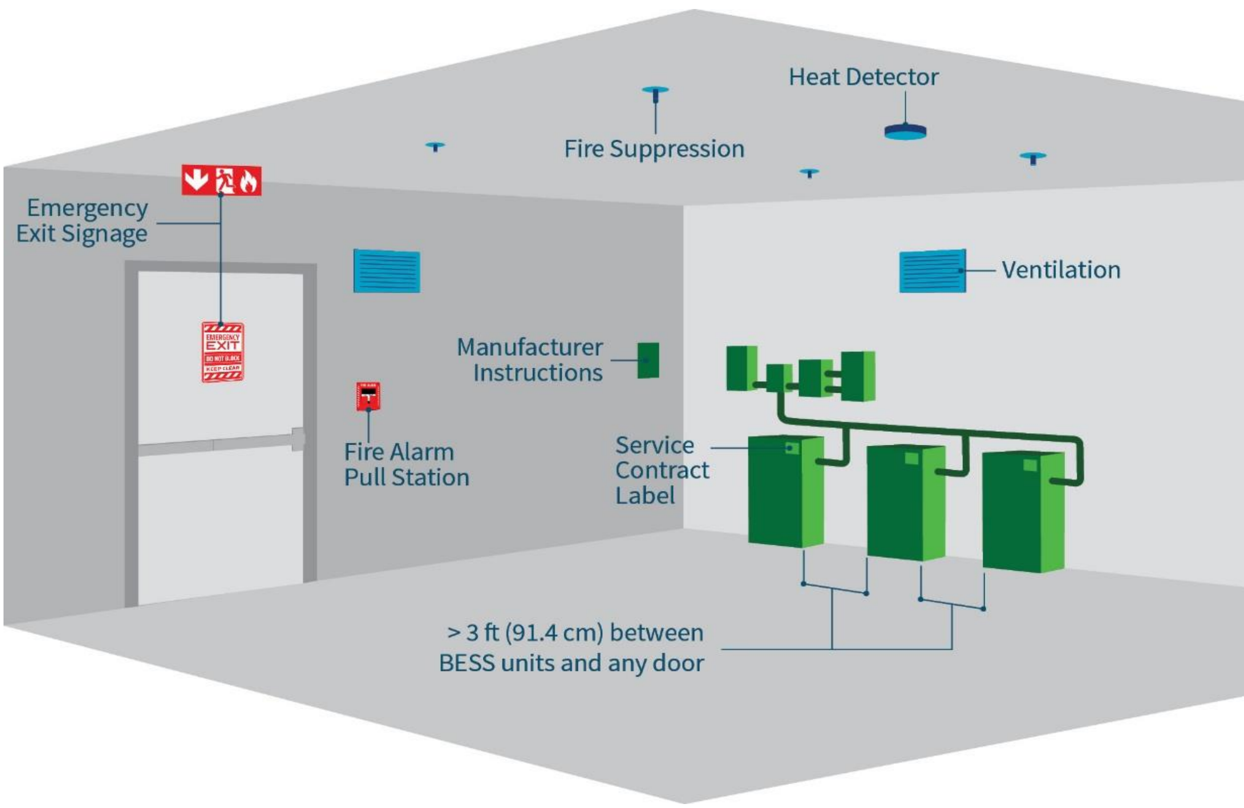

Figure 7-11: Safety Equipment for BESS Installations

7.3 Thermal Management

7.3.1 Air Cooled Systems

BESS units typically utilize air cooling for their thermal management. Air cooled systems in BESS will use a combination of ventilation, forced air convection, and air conditioning to ensure that the battery maintains a steady temperature throughout operation. Careful attention should be paid to the build-up of dust in the system as it will reduce cooling efficiency.

As explained previously, the ambient temperature of the area in which the BESS will be stored should not be more than the temperatures detailed in the product specification. If the temperatures at which the systems are operating, on average, are at the higher and/or lower operating points, this will result in more energy being used to cool/heat the system. The contractor, along with the contractor's installers, should provide these potential drawbacks to the owner when working on determining the BESS location.

There have been many technological developments made in thermal management systems for BESS units. Some systems have enabled charging the systems at temperatures below freezing which is when many other lithium batteries suffer from severely reduced charge rates. This has increased the operating temperature range of the systems and allowed for their placement outdoors in colder climates. This is achieved by the units having heaters installed to preheat the battery and improve charging performance. The heater units are generally run via grid power, although in a blackout, it can also use some of the stored energy to heat the cells, unless the battery is in a low state of charge. Ensure the contractor discusses the power draws required for running the system prior to selecting a BESS location.

7.3.2 Liquid Cooled Systems

As the BESS units increase in size, their thermal management requirements increase as well, sometimes to a point where they are more efficiently supported by liquid-cooled systems than by air-cooled systems. Typical liquid-cooled systems use a closed-loop system with a refrigerant to cool the battery cells and associated hardware.

Liquid cooling is an efficient and proven system, but the drawback of these systems is that they require additional mechanical components, which can increase the failure points that can occur within the system. Additional preventative maintenance to ensure there are no leaking, damaged, or broken components is required which will increase the operational expenses. Discuss with the contractor and or the manufacturer on the ongoing maintenance requirements, frequency of occurrence for each activity and the cost of a maintenance program for the duration of product use.

7.4 Installation

7.4.1 Construction Documents

All plans and specifications associated with a BESS (including, but not limited to, installation, replacement, commissioning, and use) need to be provided for inspection approvals. The documents shall include:

- A diagram of the location and layout of the BESS in the room or area where it is to be installed.
- The details on fire-resistance ratings provided or relied upon in the design.
- The quantities and types of BESS unit.
- The supplier's (manufacturer's) specifications, ratings, and UL listings of the BESS and its components.
- Description of the EMSs and their operation.
- Listing of all electrical components included in the design.
- Location and content of required signage.
- Details on fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems, if provided in the BESS units.
- Details on any safety systems installed external to the BESS units (smoke or heat detectors installed in the room, fire suppression systems, fencing, etc.).
- Support arrangement for mounting the units, including any required seismic support.

7.4.2 Site Preparation

Prior to installation, the site needs to be prepared to receive the BESS units and associated equipment. The area needs to be appropriately cleared, and the necessary mounting elements or buildings built (including any lighting requirements), if required. Any permits required for the site preparation should have been obtained prior to the work being started. If there are certain safety elements that must be present during the BESS installation, they shall be installed and, if necessary, tested. If any inspections are required of the site structures, ensure these are fully passed before installation of the BESS components.

7.4.3 Mechanical Integration (Mounting)

The BESS units can be quite heavy, weighing upwards of 300 pounds for the smaller units and up 20 metric tons for the large container units. The location selected for the BESS must not only have sufficient space for the unit but also be able to support the unit. Ensure all installation procedures provided by the manufacturer are followed, and that the proper lifting procedures, and equipment, for safely lifting the systems are utilized. When the space was first selected, the contractor and the installer should have checked to ensure that the appropriate lifting equipment would be able to fit and maneuver in the space.

Finally, installation of the units shall be seismically braced in accordance with the local build code. If batteries are stored on racks inside the BESS, the National Electrical Safety code states that it is not recommended to anchor racks to both walls and floors. It is recommended to firmly anchor them to the floor and design them for applicable seismic activity.

7.4.3.1 Floor Mounted Units

If the unit is floor mounted, the floor must be constructed of materials that can handle the weight of the unit. If the unit is placed outside, the mounting footprint must be properly constructed to not have the unit sink into the earth over time. The civil construction required for the site will be dictated based on the site surveys, to ensure the site placement will be a stable area to place components of this weight or to construct other structures (see Section 6.9 Location and Land Survey). A proper cement pad, or similar resting structure, shall be built with the ground properly compacted beneath it. The structure shall meet all manufacturer requirements for loading and mounting hardware required to be installed in the mounting area.

7.4.3.2 Wall Mounted Units

Wall mounted BESS units are, typically, packaged with a wall mount bracket that will work with the unit. It is important to ensure that the drilling locations are not located on any electrical wiring or plumbing inside the wall. The bracket must be aligned correctly to ensure proper mounting. Mounting the BESS on a wall may require placing it a certain distance above the floor. In this case, it is best to distribute the weight over a greater surface area and reinforce the wall. A backing structure behind the BESS with a larger surface area should be constructed and properly attached to the wall. The BESS can then be mounted to this structure. Some manufacturers may recommend having the BESS be mounted to the wall but rest on the floor instead. If that is done, ensure the floor can take the weight of the system. Indoor wall mounted electrochemical BESS are required to undergo large-scale fire testing in compliance with UL 9540A, to ensure users' safety.

7.4.4 Electrical Integration

The BESS must be electrically connected using a qualified electrical installer (please review Section 5 Selecting a Contractor). The installer shall be provided by the contractor. All electrical wiring and equipment to connect the BESS unit to the electrical system shall be installed and maintained in accordance with the Canadian Electrical Code (CEC). All components installed shall be CSA rated. Beyond the actual BESS units, the following electrical equipment will need to be installed as well to be able to operate the system.

7.4.4.1 Power Conversion System (Inverter)

The PCS is a bidirectional system that enables the flow of electricity to and from the batteries to the grid or to the load with precision control. The unit contains a rectifier to convert alternating current (AC) power from the grid to direct current (DC) power to charge the battery and an inverter to convert the DC power from the batteries to AC for use by the connected loads. When installing a BESS system ensure that there is a PCS (may be referred to as the inverter in the specifications) installed within it already that operates at the correct electrical phasing required. If it is not included in the BESS, the contractor shall ensure that a suitable part can be purchased from the battery supplier or will work with the supplier to select a compatible part. The PCS shall be listed and labelled in accordance with UL 1741 or provided as part of UL 9540 listing. Systems connected to the utility grid shall use inverters listed for utility interaction.

7.4.4.2 Transfer Switch

A transfer switch (TS) is a critical electrical component in power systems that have multiple power sources, such as grid power, backup generators, and renewable energy sources. The main function of a TS is to transfer the load from one power source to another. This can be done automatically in the event of a power outage or can be initiated by the utility or by the owner when there is a need to switch between power sources (i.e., peak shaving events, time-of-use scheduling, etc.).

In a C&I application, the facility may use an ATS but depending on the equipment that the BESS is supporting, it may be required to utilize a Static Transfer Switch (STS). STSs are utilized to protect the load from power frequency interruptions, or from any surges or dips in the grid. In contrast to ATSs, an STS uses power semiconductors to transfer between two sources. This allows for rapid transfer because there are no mechanical moving parts, allowing for the generator to provide the rapid support during grid frequency and voltage interruptions.

7.4.4.3 Critical Loads Panel

The critical load panel is a piece of hardware that functions as a second electrical panel. Instead of directly feeding the energy from the BESS into the existing electrical panel or circuit breaker, a battery will typically be designed to feed into a critical load panel to ensure that the essential appliances and circuits are backed up and not using the stored energy to feed any appliances or phantom loads that do not require to be powered.

7.4.4.4 Tie in Breaker to the Main Panel

An appropriately sized breaker for the BESS will need to be installed inside the facility's electrical panel. This is the connection of the BESS to the grid, behind-the-meter, that will provide the power from the grid to the BESS for charging and auxiliary loads. The contractor and the contractor's installers will verify if sufficient space is available in the panel to accommodate the breaker with respect to both physical space and power availability.

If there is insufficient space to physically fit the new breaker, upgrades to the panel may be required, or optimization of breakers. The qualified electrical worker will provide options when they first do a site visit and look at the panel. If the electrical panel needs to be upgraded to a high-power service, then that will require quite a bit of additional time, labour, and costs.

In addition, the panel's busbars (which are metallic strips or bars typically made from copper or aluminum; that conduct electricity within electrical apparatus and carry significant currents and distribute power across various circuits) should be inspected to ensure they are of sufficient thickness and rating. If configured in a particular way, it is possible that there could be multiple sources all feeding to the panel (in a hypothetical scenario: grid, battery, and solar). The current load of the combined sources can be in excess of the busbar rating and lead to them failing inside the panel.

Typical electrical panel power sizes for commercial buildings in British Columbia (BC) depend on the specific requirements of the load and the size of the building. Common panel sizes range from 100A to 1000A. Also, for larger commercial buildings, it is best practice to have multiple subpanels that connect to a Main Distribution Panel (MDP) to avoid taking the entire service offline during any maintenance. These considerations should also be applied when installing a BESS.

7.4.4.5 Cabling Between Components

The contractor shall follow all wiring and installation instructions laid out in the Supplier's installation guide and in accordance with the CEC. Within the guide there will likely be a requirement for cable length between components and cable size. The contractor shall plan the cable length route and ensure that there is sufficient space and cable length between components.

7.4.4.6 System Disconnect Switch

When installing a BESS, it is important to include a means to disconnect the BESS from all wiring systems. It is important that the disconnect be readily accessible, either being already located within the BESS itself, as part of the unit's design, or located within sight and within 3 m (10 ft) from the BESS as a separate component. If the disconnect cannot be located close to the BESS unit, it shall be possible to lock the disconnect as stated in the National Electrical code. The disconnect shall have clear indications of if it is "on" or "off", with "off" representing the disconnection of the equipment. The following shall also be indicated as signage on the disconnect: the nominal ESS output voltage, the available fault current derived from the BESS, an arc-flash label, the date the calculation was performed, and a warning if it can be energized.

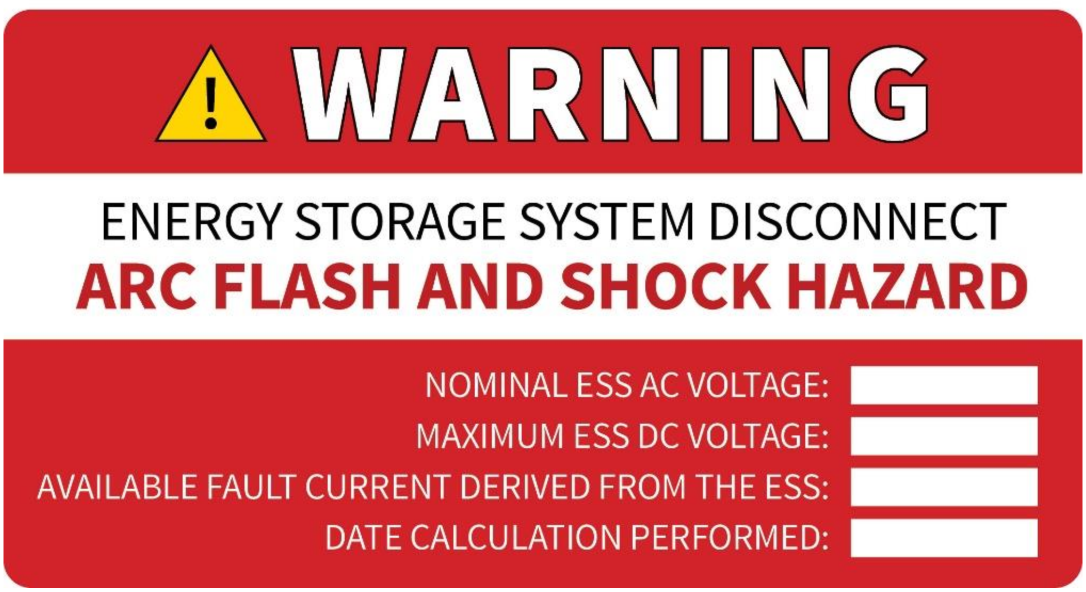

Figure 7-12: Image of a Disconnecting Means Labelling

7.4.5 Internet Connection Requirements

A normal internet connection with a minimum download speed of 50 Mbps and an upload speed of at least 10 Mbps is required to be able to monitor the installed BESS using the manufacturer's app, or online tool. In addition, if the owner will be participating in the Energy Storage Incentive (ESI) and/or the Demand Response for Businesses programs the BESS will need to be able to connect to BC Hydro's Distributed Energy Resource Management System (DERMS) to allow BC Hydro to manage the BESS during Demand Response events (see Section 9 Distributed Energy Resource Management System for additional details). This connection must be highly reliable in nature to meet the reliability requirements for the program. The ESS must be capable of receiving commands from BC Hydro through an IEEE 2030.5 certified connection, SCADA, existing API to the DERMS, or other method BC Hydro deems acceptable.

Note that each BESS manufacturer may not provide an application for monitoring their device, but if provided it is their own in-house application. At the moment there is no universal BESS monitoring application. The apps or online user monitoring tools are provided by each individual supplier.

7.4.6 Commissioning

The commissioning process ensures that the BESS and subsystems have been properly designed, installed, and tested prior to safe operation. Commissioning shall be performed after installation is complete but prior to final inspection and approval.

7.4.6.1 Commissioning Plan

The installer shall provide a commissioning plan that describes how the system and its associated safety systems shall be verified and documented as being in proper working order. Per NFPA 855, a well-defined commissioning plan will include the following information:

- Overview of the commissioning process.
- Definition of the roles and responsibilities for all individuals involved.
- Description of how the commissioning plan will be made available during BESS implementation.
- BESS plans, specifications, and associated operational controls and safety systems.
- Detailed descriptions of each activity, the individual performing the activity, and schedule position of the activity.
- Procedures to document proper BESS operation.
- Testing for any fire detection, fire suppression, thermal management, ventilation, and exhaust systems.
- Commissioning documents, including:
    - A commissioning checklist.
    - Operational testing forms.
    - A commissioning log to record activities and issues.
    - Commissioning report template.
- Means and methods on how the owners, operation personnel, and potentially maintenance staff will be trained on the system.

- Identification of personnel who are qualified to service and maintain the system and respond to incidents.
- A decommissioning plan (see Section 15.1.1 Decommissioning Plan) for guidance on development of a decommissioning plan).

7.4.6.2 Commissioning Testing

All components of the BESS shall be tested to ensure full and proper operation by the system installer employed by the contractor. The testing shall be performed in accordance with the manufacturer's instructions, the commissioning plan, and any jurisdictional requirements. The specific testing required will vary from product to product, and the list below is not meant to be the complete list of potential commissioning tests, but broadly will include the following:

- Mechanical checks – ensuring components are properly secured and testing of mechanical components as part of BESS units. Verify:
    - All units are in good physical condition and contain all pertinent safety information.
    - All labelling is performed appropriately.
    - All connections between electrical components are complete.
    - Communications wiring is properly installed.
- Safety systems check (external to BESS) – ensure components installed as a result of installation of the BESS but are not a part of the BESS system or BESS controls are installed correctly and working (examples include the fire suppression system and smoke/heat detectors).
- Cold commissioning – testing of BESS prior to energizing system from main power grid. System is supplied with only auxiliary power to run basic controls and life checks. Activities may include:
    - Confirmation units have internet connectivity.
    - Confirm activation of unit's cooling system with no issues or alarms.
    - Confirm system is conducting health checks (SOC, SOH, etc.).
    - Ensure system's battery pack has cells that are appropriately balanced at the module, rack, and enclosure levels.
    - Confirm PCS units are communicating with EMS and BMS and all user portals are available to access and running.
    - Confirm communication of each unit with the internet portal.
    - Conduct system safety checks to ensure there are no alarms on the system.
    - Conduct any final electrical safety checks prior to energization from the grid.
- Hot commissioning – energization by the grid of the BESS and BESS to facility.

- Final performance testing – ensuring system can be fully charged to 100% SOC and can be discharged at nameplate power to connected load components.

7.4.6.3 Commissioning Report

The system consultant, or commissioning agent, shall provide a final commissioning report to the owner. The report shall summarize the commissioning process and verify the proper operation of the system. The report shall include the final commissioning plan, the results of commissioning, a copy of the plans and specifications of the as-built system, and a list of any issues identified. Any open issues shall require a corrective action plan developed to address each issue. The BESS cannot be placed into service until the corrective action plan is accepted by the AHJ (inspector of the TSBC, or another jurisdiction inspector).

The report should be kept with all documentation pertaining to the Operations and Maintenance of the equipment.

7.4.7 Required Documents

When installing a BESS, the following documents should be made available:

- Product specifications.
- System designs.
- Installation guide; for proper installation of the BESS unit and necessary equipment.
- Operations and Maintenance, or service, manual; these should be made readily available next to the installed BESS.
- Warranty manual: for replacement or repairs by the manufacturer where applicable.
- Commissioning plan: a written document outlining the steps, tasks, activities, and responsibilities to be conducted and adhered to for how the system and its associated safety systems shall be verified and documented as being in proper working order.
- Emergency Response Plan (ERP): refer to Section 11.4.1 Emergency Response Plan (ERP) on the ERP. It is a document that outlines the procedures and responsibilities for responding to an emergency or issue with the BESS.
- Decommissioning plan: a written document outlining the steps, tasks, activities, and responsibilities to be conducted and adhered for safely de-energizing and removing a BESS.

7.4.8 *Installation Process*

The following is a generic installation process to provide an outline on the potential steps for a BESS build. There may be additional steps that have not been included below, or fewer, depending on the complexity of the installation.

1. Research contractors to conduct a feasibility study for the facility.
2. The contractor shall carry out the study to determine areas where energy efficiencies can be improved in the facility.
3. Review feasibility study results with the contractor to determine BESS Use Cases.
4. Either decide to continue with the current contractor, or research others and, once properly vetted, select.
5. The contractor, and possibly the contractor’s installers, shall perform a site visit to view potential installation location for the BESS and associated equipment.
6. Work with the contractor to obtain proper sizing based on the Use Cases determined from the study.
7. Obtain a quote and thoroughly review the terms and conditions of all items. Pay close attention to warranty conditions and inquire if there are any service agreements that can be obtained with the supplier (usually reserved for larger installations).
8. Once an offer agreement has been made for incentives, the owner will decide to enter a contract with the contractor.
9. The contractor shall submit any applications (for incentives or other programs).
10. The contractor shall complete a site survey to determine if the BESS placement is feasible. The contractor shall also obtain any permits necessary to be able to install the BESS units onsite.
11. The contractor shall complete the necessary design work required for the installation. Any subcontractors that need to be brought in to complete any design work for the installation outside of the capabilities of the contractor (example civil engineering for load studies, cement pad design, or building construction) shall need to be procured.
12. The contractor shall procure all equipment. Typically, the batteries will have the longest lead time.
13. Prepare site for BESS installation. This could include cement pad pouring, vegetation removal, groundwork, or a full-building construction. In addition, all necessary lifting equipment shall be procured to properly lift and place the equipment.
14. Unpack and inspect all equipment. If any equipment is damaged do not use.
15. Transport equipment using appropriate lifting equipment to location.
16. Mount BESS using the designs developed by the contractor taking into account all the supplier’s installation instructions.

17. Install associated electrical equipment for the system.
18. Make the electrical connections between components and systems.
19. Complete necessary safety checks between components and verify mechanical connection of all components.
20. Carry out commissioning plan.
21. Complete final testing of the system.
22. Following the installation of the BESS, safety inspections will have to be carried out by the relevant electrical safety authority (TSBC typically or the local municipality's safety authority).
23. Carry out training on the operation of the system, inform personnel on-site of safety hazards associated with the system, ensure owners and/or site personnel with access to systems have access to the monitoring applications for the system.
24. The contractor shall provide any training, education, or general assistance to the customer to enroll device into Demand Response for Business Behaviour, or any other BC Hydro BESS Incentive Programs.
25. Provide all documentation to the owner. This will include all reports completed, system documents, and planning guides for operations, emergencies, and installation.

8. System Costs

The battery is the largest cost component accounting for 60–70% in a typical BESS installation. Hence, the technology costs dictate the costs of the batteries. As much of the BESS market is made of Li-ion and lead acid batteries, the approximate costs presented here will be based on these technologies. Although the BESS prices have seen a rapid decline over the past decade, an end user should be prepared to invest a significant amount for the installation.

In terms of upfront costs, lead acid batteries are cheaper than the Li-ion for same usable capacities. However, as lead acid has a lower maximum DoD (50%) compared to a lithium ion (98%), twice as many lead acid batteries are required to obtain the same usable capacity as the lithium-ion batteries. A LiB also tends to have a longer lifespan by 3–4 years over a lead-acid battery.

The overall system installation cost for commercial systems ranges from 700 – 1,600 $/kWh. The difference in the cost is primarily due to the savings through economies of scale. Due to the modularity of BESS, a C&I entity could install multiple units to meet its large energy needs. BC Hydro is offering programs to assist businesses with purchasing and installing BESS unit through an incentive program (see Section 10.4.1 Commercial Rebates for details).

Some providers may offer leasing arrangements or payment plans that can be accessed. It is recommended that the owner check the details and ask for the total costs of any plan.

Once installed it is recommended that a maintenance plan is purchased to ensure the battery is running safely and efficiently. Speak to the contractor about any ongoing maintenance plan options and costs.

9. Distributed Energy Resource Management System

Distributed Energy Resources (DERs) are small-scale electricity assets that feed electricity (supply) into and take electricity (demand) out of the larger utility network. These assets include diesel or natural gas generators, microturbines, solar arrays, small wind farms, battery energy storage systems, and other power generation resources. They are usually located closer to load centres and can be used individually or in aggregate.

A distributed energy resource management system (DERMS) is used to manage these resources. A DERMS is the combination of hardware and software that allows real-time communication and managed across the DERs. There are several DER aggregation methods, such as Virtual Power Plants (VPPs), microgrids, aggregator platforms, and price-based control. As an example of a DERMS application for BESS units, the aggregation software may ask for certain individuals to participate in a peak demand event and not others based on the constraints set for each asset. Later, the software may initiate BESS charging at a time when there is peak supply for certain assets. As a result, DERMS allow grid operators to smooth out peaks and valleys across the grid to better manage energy production and power distribution.

BC Hydro has implemented their own DERMS solution as part of their Energy Storage Incentives (ESI) for Business and Demand Response for Business Behaviour programs. An owner can enter a contract with BC Hydro (10-year contract duration) to allow for BC Hydro to have access to a certain amount of battery capacity for a four-hour duration. The energy being discharged from the BESS is not being transferred to the grid -- the BESS is simply providing power to the connected loads at the facility during the dispatch event. Dispatch events are periods when BC Hydro wants to bring down peak demand and engage in Peak Shaving.

To participate in one of the programs, the BESS must connect to the BC Hydro DERMS platform (refer to the Energy Storage Incentive - Customer Manual, Section 2.4.2 for a description of BC Hydro's DERMS platform) to receive automated dispatch commands. This connection must be highly reliable to meet the reliability requirements for the program. Commands from BC Hydro shall be received through an IEEE 2030.5 certified connection, SCADA, existing API to the DERMS, or other method that BC Hydro deems acceptable. Manual control of the battery to fulfill event commands is not permitted. It is the customer's responsibility to ensure that their connection of choice meets these criteria and that it remains operational for the duration of the 10-year contract.

The ESI program is described in Section 10.4.2 Energy Storage Incentive.

10. Current BC Hydro Program Offerings

This section will cover the initiatives from BC Hydro for BESS installation. Federal initiatives, if any, are outside the scope of the guide. For the most current details, please refer to official program websites, as information may change over time.

10.1 Feasibility Study

An energy expert will conduct an in-depth study and evaluation of energy solutions within a single or multiple systems and provide the cost/benefit details to the customer. BC Hydro provides a funding program to assist business customers with financing a feasibility study.

For more information, go to Feasibility Study.

Table 10-1: Potential Funding Options for Business Customers

Item	Description	
Incentive	**Project Type**	**Potential Funding**
	Energy opportunity of more than 200,000 kilowatt-hours (kWh) per year, or a total demand impact of more than 100 kW.	100% funding
	Energy opportunity of 25,000 - 200,000 kilowatt-hours (kWh) per year, or a total demand impact of 25 - 100 kW	50% funding
Eligibility	• Available to industrial and large commercial customers. • Large commercial customers must have company-wide, annual electricity consumption of at least two gigawatt-hours (GWh). • For energy-efficiency or low-carbon electrification projects, the minimum energy opportunity must be at least 25,000 kWh per year. • For demand-response projects, the minimum demand impact must be at least 25 kW.	
Application Process	Applications are submitted by the Key Account Manager or Regional Energy Manager. Contact them to apply. If unsure who to talk to, contact the business help desk at 1 866 522 4713.	

10.2 Demand Response for Business Behaviour

The Demand Response for Business Behaviour program allows businesses to earn rewards for shifting electricity use out of peak demand periods. A demand-response event is a period of high demand (lasting no more than 4 hours at a time), in which if a participant shifts the typical electricity use to before or after the event, they will earn a reward. A participant may apply and take part in both the ESI and Demand Response programs.

For more information please see the following link: Demand response for business.

10.2.1 Program Details

Table 10-2: Demand Response Program Details

Item	Description
Incentive	Incentive ($) = $50 / kW-season * seasonal average demand reduction (kW-season).
Duration	Maximum duration (hours/event): 4.

Item	Description
Eligibility	The business must be on BC Hydro's small general service (SGS), medium general service (MGS), large general service (LGS) rate or have designated BC Hydro Key Account Manager. The business must have operated at the current address for at least one year. At least one dedicated person on staff will need to receive and respond to events. Carbon-intensive energy sources cannot be used to reduce the business's BC Hydro electricity use (includes gas and diesel generators).

10.3 Self-Generation

The self-generation program allows owners of independent generator sources (typically rooftop solar PV systems) to feed excess electricity back to the grid in exchange for a generation credit towards future electricity use. Some of the excess electricity can be stored in a BESS that is connected to the system, but even with this inclusion there are occasions where the amount of energy generated (in a day) will exceed load requirements and charge the BESS to full capacity. This energy can then be sent to the grid rather than having it curtailed. A bi-directional smart meter measures the amount of electricity consumed from the grid, as well as the excess that has been sent to the grid. Excess generation is credited to the owner on their next bill, but if there are still generation credits remaining on the owner's anniversary date, BC Hydro will pay for the excess electricity at market price.

Incorporating a generation unit and a BESS for storage of energy, while still being connected to the grid is a very complicated electrical project. All components shall be properly sized to handle loads coming from all the sources and each of the pathways shall be properly protected to prevent potential back feeding, short circuit, or any other electrical issue.

For complete eligibility and program details, see Self generation for the eligibility criteria.

10.4 BESS Incentive Program

10.4.1 Energy Storage Incentive

BC Hydro offers incentives for businesses to adopt Energy Storage Systems (ESS). Once installed, BC Hydro can automatically dispatch the ESS to respond to grid conditions. During dispatch, the battery discharges to power the facility and reduce grid demand, then recharges later in the day or overnight. Refer to program at the following link: Energy storage incentive.

10.4.1.1 Application Process

See the energy storage system (ESS) application process for details. You'll also need the incentive application workbook to begin the process.

10.4.1.2 Program Details

Table 10-3: Energy Storage Incentive Program Details

Item	Description
Incentive	The incentive provided is based on the amount of capacity the customer allocates as available for demand flexibility or demand response events. The incentive is calculated as the lesser of: • $10,000 X kW nominated. • $10,000 X kWh/4 nominated. • 80% of eligible project costs.
Duration	10-year contract to provide demand flexibility services via the BESS to BC Hydro. Shall provide year-round services within the following parameters: • Maximum duration (hours /event): 4. • Maximum daily frequency: 2. • Minimum hours between events: 5.
Eligibility	Be on a general service or irrigation rate under the Electric Tariff. Plan to install a new battery. Batteries that have already been purchased or installed are not eligible. Have an operating smart meter. Must complete applicable net metering or generator interconnections process. Systems must be non-exporting to the grid. Must install and energize an ESS that meets all the system requirements of the program within 24 months of completing a distribution generator interconnections facility study or the net metering application process. Must reliably respond to flexibility dispatch events. Performance is considered reliable when the ESS is charged to provide at least 85% of its nominated capacity for 85% of all demand response events, as measured at the start of the event. Reliability is assessed annually. Must connect to BC Hydro software platform via IEEE 2030.5, SCADA, established API or other method approved by BC Hydro to receive event signals.

11. BESS Operations and Maintenance

Once properly installed and fully commissioned, the BESS can provide the services it designed to provide. All BESS are to be operated in accordance with the manufacturer's instructions. To ensure the long-term availability of the BESS to provide said services it must be in good working order. The necessary activities required to keep the BESS functioning correctly is known as Operations and Maintenance (O&M).

It is possible to obtain a long-term maintenance plan (Long Term Service Agreement) either with the contractor if they offer such a program, or with the supplier. The plan will include scheduled preventative maintenance activities, as well as plans for unexpected issues requiring corrective maintenance.

Having a robust O&M plan will lead to the following outcomes:

- Increasing safety.
- Managing costs.
- Maximizing performance.
- Providing high availability of equipment.
- Prolong the lifespan of equipment.

11.1 Operations Training for Owners

The contractor's installers will set up the system and will provide training on how the BESS functions post installation. This will include the different operating modes available and how they will interact with the equipment in the building. The system may have settings that can be adjusted. For example, utilizing the settings features of the application or the human-machine interface (HMI) for the BESS, an owner can opt to set that the BESS only charge at certain times of the day and discharge at other times to coincide with time-of-use programs or to get the most out of enrolled programs with the utility. It is important to note that not all battery storage systems have the same functions. As discussed previously, ensure, upfront, that the battery selected for the use case will suit the owner's needs.

11.2 Monitoring of the BESS

Most BESS offerings provide an application that can be downloaded to the owner's smartphone or computer to allow for monitoring of the system in real time. Using the application allows owners to track their usage and monitor the BESS capacity and power input and output. Accurate tracking of the BESS system parameters requires the unit to be connected to Wi-Fi and for the unit to be properly registered with the manufacturer. It is recommended that the monitoring portal be checked at least once a month to make sure it is working properly. In addition to providing a live feed of the BESS, the monitoring system will maintain their historical values in a large database, usually uploaded to a cloud platform.

During operation, if any values of the system fall outside the normal bounds of operation, this can trigger a warning. The control system in the BESS will send out a warning and then mitigate the issue in the system (example disconnecting the BESS). This warning will be sent via an alert to inform the owner immediately to the issue. In some cases, the alert will also go to the supplier to inform them of the issue and have corrective maintenance personnel investigate it.

11.3 Maintenance

11.3.1 Maintenance Activities for C&I BESS units

As the size of the BESS increases, and the systems within the BESS increase in intricacy, the maintenance activities required become increasingly more complex and frequent to perform. These activities include a combination of preventative and corrective maintenance. The owner of the BESS may be able to take on ownership of the maintenance activities for the system, provided they have the necessary expertise and requisite training, but it is more likely that the owner will need to engage in a contract with another firm to maintain the facility. This can be potentially done with the contractor, a qualified third party, or the BESS supplier itself.

Most suppliers can offer their customers an all-inclusive agreement for the maintenance of the system. The agreement will cover the project from delivery to a set term (typically 10 to 15 years), most likely not the end-of-life of the product. This is commonly called a Long-Term Service Agreement (LTSA). There may be additional items included in the LTSA, that are described in Section 12.2 Long Term Service Agreements, but the overarching purpose of the LTSA is to ensure that the battery supplier is responsible for their product and maintaining it. Enquire with the contractor, and or the supplier, if an agreement is offered to take care of these services. Obtaining an LTSA will cost additional money, but suppliers can offer tiers of service from performing all O&M activities, with 24 hour 7 days a week monitoring (high-end coverage) to performing a subset of that service for reduced costs. The owner should explore their options for LTSAs with the contractor or supplier and determine what responsibilities they need to have taken care of for them and if they can support the costs of those services.

Note, an entity that the owner has engaged to purchase from or install the systems may only provide a contract to cover select components. Read all contracts thoroughly to ensure that all responsibilities are fully covered for the equipment. Additional contracts may need to be obtained from other parties for the additional components.

11.3.1.1 Preventative Maintenance Activities

Preventative Maintenance (PM) activities are typically performed either by the battery contractor or by a subcontractor authorized by the battery supplier to perform the work. The personnel must be trained to work on the equipment and possess certifications from the supplier that they have gone through the relevant training programs. The average period for routine maintenance is every 6 months, and annually for capacity testing and maintenance of more complex systems. Service requirements will differ from product to product, so it is imperative that the personnel performing the activities familiarize themselves with the maintenance manuals provided by the supplier and ensure they are kept up to date.

Table 11-1 lists some of the typical PM activities that may be routinely performed.

Table 11-1: Examples of Preventative Maintenance Tasks

Task	Description
Regular cleaning and visual inspection	Visually check for damage, corrosion, or leaks
Harness inspection	Visually inspect power and cable harnesses to ensure there is not damage to the cables or exposure hazards
Pest inspection	Visually inspect for presence of pests
Cooling system	Inspection of filters, filter replacement or filter cleaning, testing HVAC units, checking cooling fluid pressure, level, damage to cooling tubes, and cleaning of ventilation pathways
Battery connection verification	Inspect connections to battery terminals to ensure they are properly torqued
Bolt torque inspection	Ensure all mechanical connections have not loosened by checking torque marks or by checking physically with a torque meter
Review of temperature logs	Review temperature logs to verify if there have been any localized high temperature events
Fire protection systems testing	Verify functionality of smoke sensors, gas sensors, ventilation systems, and alarms. Verify alerts are being properly sent to first responders
Installation of software updates	Ensure the software is up-to-date and implement any bug fixes
Network Equipment	Verify connections and functionality of all communications gear
Data Historian	Check to ensure proper backups are being performed, investigate data anomalies, and ensure no data losses have occurred

It is the responsibility of the owner to ensure that the system is maintained. Work with the contractor to determine a maintenance schedule for the equipment based on the Maintenance Plan provided by the supplier. Records the maintenance schedule events in an official calendar and ensure that they are fulfilled and maintenance logs properly maintained.

11.3.1.2 Corrective Maintenance (CM) Activities

Corrective Maintenance (CM) covers maintenance tasks when an unexpected event occurs. The activities include work to identify, isolate and repair a fault in order to restore the system to an operational condition. It is important for the service provider to have fast-acting service providers to perform the corrective work quickly. Most contracts with service providers will include clauses for required response time for corrective maintenance events. Post completion of the corrective maintenance a root-cause analysis (RCA) should be completed to ensure the issue has been found and reoccurrence will not happen. Table 11-2 lists examples of CM events that may occur.

Table 11-2: Examples of Corrective Maintenance (CM) Events

Event	Examples
BESS unit CM	Cell/module overheating, voltage imbalance, loss of sensor functionality, or capacity degradation
PCS unit CM	System overheating, or slow response times
Communications/network CM	Inability to communicate between units, loss of communication, or slow reaction times
Enclosure CM	Damage to enclosure

11.3.1.3 Spare Parts

Many maintenance tasks will require replacement parts, requiring that storage space for common consumable parts be provided on-site. Having components on-site ready for replacement periods reduces downtime, lead time, and shipping. Recommended spare parts and quantities can vary greatly depending on the product and the supplier recommendations. Although, it is helpful to have the parts on-site, this will increase upfront costs for the facility and require site management duties to inventory and maintain the storage location of the components. In addition, components must be stored in a location that will meet their storage specifications.

The owner should work with the contractor to determine the necessary components that should be stored on-site (if spare parts are needed), the space required for spare components, and if the storage space can meet the storage requirements of those components. Space requirements may be limited which will limit what components can be stored. The owner should also check if these components are supplied as part of any long-term agreements and are thus already included in the yearly agreement costs.

11.3.1.4 System Testing

It is recommended to schedule and perform an annual (once a year) check of the operating status and connection status of the BESS. This shall be conducted by a qualified technician or authorized installer. When performing this system test, the accredited contractor can provide the owner with feedback on the system’s performance and help the owner to understand their usage and the system’s limitations. Request that a record of the test be provided by the test performer for system records retention.

11.3.2 Operation and Maintenance Documentation

The O&M documentation shall include the following:

- Procedures for safe startup of all equipment associated with the BESS.
- Inspections and testing procedures for alarms, interlocks, and controls.
- O&M procedures for the BESS components including, where applicable:
  - BMS and EMS.
  - Fire protection systems and equipment.
  - Exhaust ventilation systems and equipment.
  - Gas detection systems.
  - Any other safety systems and equipment.
- Response considerations to address safety issues.
- Method of recording system changes to the BESS installation, and an instruction to update engineering documentation when significant changes are made to equipment.
- Detailed maintenance schedule.
- Maintenance checklist or form to indicate the maintenance activity taken, date, personnel who completed the activity, and results of action.

Any repair, renewal, or renovation made to the BESS shall be recorded and documents retained. All documents shall be provided to the owner.

11.3.3 Maintenance of Additionally Installed Systems

Additional systems installed as a result of the installation of the BESS units will typically not be included in the scope of any agreement with the supplier or contractor for BESS maintenance. It will be up to the owner to ensure proper operation and maintenance of these systems installed within their site. These systems should be integrated into existing site maintenance plans and schedules, with records of maintenance being completed and retained, if required. Additional maintenance tasks may include:

- Verification of smoke alarm or heat detector operation.
- Ensure all signage is in place, visible, and legible for readers.
- Fire suppression systems, or items, are properly inspected and tested, if required.

11.3.4 Approximate O&M Costs

For C&I systems, various institutions have provided approximations of the costs of different aspects of the BESS units, utilizing the experience gained from different projects. Pacific Northwest National Laboratory (PNNL) publishes this information online (Lithium-ion Battery (LFP and NMC) | PNNL). Utilizing this information, it can provide an approximation of anticipated O&M per year. Table 11-3 shows the approximate yearly operating costs for a BESS for various sizes.

Table 11-3: Approximate Yearly Operating Costs

Duration (hrs)	2	4	6	8
Operating Costs [$/(kw-year)]*	4.56	7.88	10.05	12.61

*Values converted from USD to CAD at a conversion rate of 1.44 CAD to USD (March 26, 2025, date of conversion).

As an example, if the owner plans to install a 4-hours BESS unit that is a one MW power capacity (4 MWh energy storage capacity), the approximate O&M costs per year would be $7,880 per year. These costs, though, are not the costs detailed from a LTSA and only represent the O&M work on the system itself. These costs do not consider costs of transportation, lodging, and other such expenses for qualified personnel and are simply the costs of maintaining the system. Obtaining an LTSA will cost additional money, but suppliers can offer tiers of service from performing all O&M activities, with 24 hour 7 days a week monitoring (high-end coverage) to performing a subset of that service for reduced costs.

11.4 Safety

The most severe safety risks associated with BESS are fire, explosion, and electric shocks. Other common risks include toxicity due to leakage of chemicals. However, storage system components (including batteries) are required to follow stringent international, federal and provincial quality standards before entering the market. These standards include guidelines on performance quality and safety requirements. As such risk of severe failure in BESS is low.

Modern BESS have a battery management system (BMS), which continuously monitors the battery's state, including its voltage, current, temperature, and state of charge. This informs the end user about unsafe states such as overheating and overcharging. The BMS can take corrective actions such as disconnecting the battery, enabling the alert mechanism, or activating the cooling systems.

The major safety hazards and their mitigation strategies are presented in Table 11-4. Besides these targeted mitigation strategies, the following general steps are recommended for all BESS technologies and installations:

1. Training and education:
    - Owners and people working with BESS should receive training and education on proper battery operations, maintenance, and emergency procedures.
2. Selection of appropriate BESS technology:

- Ensuring the safest battery chemistry is selected will aid in mitigation of potential hazards.
- The safety systems included with the BESS should be proven to aid in mitigating a hazard should one arise (electrical protection equipment, BMS, fire suppression systems, fire detection systems, etc.).

3. Designing to the codes and standards:
    - All equipment selected and the BESS site shall be designed to, certified to, or in compliance with, appropriate codes and standards.
4. Hazard labels and signage:

Figure 11-1: Common Hazard Labels Associated with BESS

- Appropriate signage should be installed at the entrance to the BESS installation area.
- Signs should be installed in a light-reflective surface.
- The signs should include information on:
    - BESS technology installed.
    - Potential hazards.
    - Personal Protective Equipment (PPE).
    - Emergency contact.
    - Fire suppression system in the area.
- The location of disconnecting means should be properly displayed for all BESS on or in premises.

5. Emergency response plan (ERP):
    - C&I units with BESS installations should have a clear emergency response plan outlining steps to take in case of battery-related incidents, such as overheating or fire. Details of an ERP are presented in Section 11.4.1.

Table 11-4: Major BESS Hazards, Safety Risks, and Mitigation Strategies

Hazard	Risk	Occurrence Phase	Description	Mitigation
Falling loads	Physical damage	Installation, Maintenance	BESS units are heavy (can be approximately 300 lb) and can fall on installers during installation.	Installation by trained professionals while following manufacturer recommendations and local standards.
Incorrect lifting	Physical damage	Installation, Maintenance	Lifting of heavy loads can cause damage to the body if lifted incorrectly.	Following proper safe lifting procedures and following installation guides.
Electrical	Electrical shock / short circuit	Installation, Operation, Maintenance	Batteries can never be fully discharged, as that will damage them. There will always be energy present in the unit, even when it is disconnected.	Weatherproof enclosure for electrical components. Maintenance by trained professionals only.
Thermal Runaway	Fire, Explosion	Installation, Operation, Maintenance	Thermal runaway is a chain reaction within a cell that is accelerated by increased temperatures. The result of thermal runaway is that the cells heat to a point where they can explode and/or catch fire.	Limit overcharging, install fire detection and suppression mechanisms, use of certified BESS components, properly functioning thermal management and HVAC system. Most BMS software platforms have early abnormality detection systems.
Off-gassing	Toxicity, Suffocation, Fire, Explosion	Operation, Maintenance	Release of built-up gases that can be toxic or cause suffocation in less ventilated areas. The released gases could also be highly flammable.	Installation in a well-ventilated area. HVAC system for ventilation and gas detection sensors.
Arc Flash	Fire	Installation, Maintenance	Unintended short circuit of electrical equipment that results in a sudden and dangerous release of energy. Dangerous arcs are more likely in high-voltage systems, so they are important safety hazards to prepare for in C&I applications.	Only skilled workers with required PPE should work with electrical modules involving BESS.
Chemical	Corrosion, Skin Injury	Installation, Operation, Maintenance	Some BESS technologies such as lead acid have chemical leakages as they age. This damages the nearby components.	Regular inspection and cleaning of batteries to ensure that corrosion signs are detected early.

11.4.1 *Emergency Response Plan (ERP)*

A facility that has a BESS shall have an Emergency Response Plan (ERP) available and onsite for use by designated personnel (owner, facility maintenance caretaker, O&M personnel). The ERP shall include information on the following:

- Detailed procedures to safely shut down, de-energize, or isolate equipment and systems during emergency conditions. These procedures reduce the risk of fire, electric shock, and personal injury.
- Procedures on how to respond to notifications of system alarms and the system operating outside of normal operating conditions. These may include shutting down equipment, calling service personnel, and notifying emergency personnel (fire department), if required.
- Emergency procedures to be followed in response to potentially dangerous conditions. Examples include, but are not limited to fire, explosion, off-gassing, and damage to moving parts.
- The emergency response plan should include a fire emergency plan that details:
  - Personnel evacuation and equipment isolation strategies.
  - Critical information for fire services, such as detailed contact information and standardized communication protocols for emergency situations.
  - Available fire fighting measures available in the installation area.
- Detailed responses on how to mitigate safety concerns for emergency events.
- Procedures on handling damaged BESS equipment, after an emergency event. This will include contact information for qualified personnel to safely remove damaged BESS equipment from the site.
- Additional procedures to provide for safety considerations of occupants and emergency responders.
- Procedures for conducting drills and a schedule on when drills will be conducted.

If any changes occur to the system, the plan shall be updated to reflect those changes. The BESS owner and onsite personnel should be trained on the ERP after the installation of BESS.

Development of the ERP can be performed by a qualified installer or contractor. It is best, though, to have the plan developed by the original contractor who has intimate knowledge on the design of the system.

12. Warranty and Long-Term Service Agreements

12.1 Product and Installation Warranties

The equipment should come with a warranty declaring that it will be free from defects for the warranty term following its initial installation date (or it may be by purchase ate, pay close attention to wording) and it should also have an energy capacity retention guarantee. An energy capacity retention guarantee is a promise provided by the supplier that for a duration of time, or for a cumulative throughput of energy, the capacity of the BESS will stay above a certain threshold (usually denoted as a percentage of the nameplate value). For example, if the original nameplate value of the BESS is 12 kWh and the supplier warrants that for 10 years of operation the capacity will be above 80%, then for those ten years the capacity of the BESS will be greater than 9.6 kWh. If the capacity dips below that point during the warranty period, then the BESS shall be replaced or refurbished by the supplier, provided the BESS was never used outside of the terms and conditions specified in the warranty. Review in detail the terms and conditions of the warranty. If the warranty conditions are not met for any reason the supplier can limit the warranty or completely cancel it.

In addition to the product warranty, the contractor should provide a warranty for the installation of the system. A contractor's warranty is a written promise by the contractor to repair or replace a defective product (that is only defective because of the installation) or correct defective workmanship. The warranty will cover components installed by the contractor for a set term.

12.2 Long Term Service Agreements

As discussed previously, an owner may engage in a Long-Term Service Agreement (LTSA) with the supplier to provide O&M services for a certain period. In addition to those services, the LTSA may also provide the owner with an extended warranty for the supplied equipment, for the operational duration, and provisions for Performance Guarantees of the BESS. Under these provisions the supplier commits to achieving certain metrics each year, while the LTSA is active. Typical metrics for the performance guarantees are State of Health (SOH), Round-Trip Efficiency (RTE), and availability. Some metrics will have a minimum threshold, like availability (example minimum 97%), while others will have diminishing values year-over-year, such as RTE. The LTSA will remain in place if payments are made (typically annually) and the other terms within the agreement are met by the owner. Obtaining an LTSA will cost additional money, but suppliers can offer tiers of service from performing all O&M activities, with 24 hour 7 days a week monitoring, and covering several guarantees (high-end coverage), to performing a subset of that service for reduced costs.

13. Insurance

As previously stated, adoption of an on-site BESS at a commercial or industrial building is a relatively new technology. Many other industries have yet to need to deal with BESS, which includes the insurance industry. Installation of a BESS can significantly impact an owner's insurance, and it's essential to understand how these systems fit into an owner's existing coverage. Most standard insurance policies can be adapted to include BESS, but the owner will need to inform their insurance provider about the installation. Failure to do so will result in potentially loss of coverage should an issue occur because of the installation.

13.1 Concerns Requiring the need for Insurance

In previous sections of this guide the safety concerns and need for installation of a certified BESS by a qualified installer have been reinforced and these should be considered when requesting coverage. In addition, the owner should work with the installer and enquire about any insurance coverage concerns they should consider. When requesting insurance from their policy provider, the owner should consider the following items as a minimum:

- Insurance to cover equipment breakdown: The warranty for BESS equipment may only cover certain equipment and corrective maintenance. Malfunctions in batteries, inverters, and controllers are common risks, and insurance may be able to cover the costs of repairs and replacements for both hardware and software failures.
- Fire Hazards: As discussed, lithium-ion batteries, used in BESS, are susceptible to thermal runaway, leading to fire hazards. Sufficient fire insurance coverage needs to be maintained.
- Natural Disasters: BESS units are often installed outdoors, exposing them to risks from natural disasters. Insurance policies can be obtained to cover damages from such events.
- Third-Party Liability: If a system failure causes injury or damages property, insurance helps cover these third-party claims.
- Cybersecurity Risks: Cybersecurity is an emerging concern as BESS relies on cloud-based EMS for data monitoring and storage of information. Coverage for cyberattacks is becoming a critical component for BESS.

13.2 Insurance Request Process

The installation of a BESS on the owner's property is defined as permanently installed equipment on the premises. The facility can obtain insurance to cover this installation, but only if the insurance policy provider is properly notified of the installation, before any equipment is installed. When installing a BESS on the property, take the following steps to obtain insurance:

1. Discuss with the installer on insurance needs, considering the list in Section 13.1, and what coverage is recommended.
2. Perform the necessary research from the policy provider, or from other policy providers, to see if the provider has experience offering this insurance coverage.
3. Collect information on the equipment that is planned to be installed and the installer's professional capability and experience. Some insurers may require specific safety certifications or professional installation to provide coverage.
4. Discuss insurance coverage needs with the provider based on the coverage needs. BE sure to highlight any advanced safety features or smart monitoring capabilities, which may yield discounts for the system.
5. Obtain a quote for the coverage required.

It shall be noted that there is not a significant penetration of BESS installations, and a lack of data and statistics probably will result in insurance premiums increasing for the owner to cover this new asset, and the potential risks. Policy providers will want to see greater penetration of BESS before fully recognizing it as an improvement that adds value to the business.

13.3 Potential Information Requested from Insurers

It is important to have as much information available for your own personal records, and to provide it to the insurers if it is requested. Information pertaining to the installed safety systems, emergency response systems and plans in place, as well as the qualifications of the suppliers and the contractors, may result in a decrease in costs for the owner. The owner should work to obtain the following at a minimum:

- The battery cell manufacturer (information on their history, reputation, and standards certified).
- The main contractor for the project (experience, reputation, and standards).
- Fire detection systems installed.
- Fire suppression systems installed.
- System protection measures.
- Heating and cooling systems.
- Systems monitoring.

- Emergency response procedures.
- Design of the installation (including layout, and spacing between battery cabinets or containers).
- Site security equipment (fencing, CCTV, alarms, monitoring, cyber security).

14. Lifetimes and Degradation

14.1 Typical Battery Lifespans

BESS units typically have lifespans of about 10 to 15 years. The lifespan depends on the number of charge-discharge cycles that a battery goes through.

14.2 Degradation Over Time

Over time, the batteries will slowly begin to lose the amount of energy they can store, referred to as battery degradation. Battery degradation will result in reduced energy capacity, power, and overall efficiency of the BESS. Battery degradation is not easy to predict. Every battery supplier will have different degradation rates, and how the owner uses the battery will impact that degradation. On average, in the first year, there will be the highest degradation of approximately two to three percent, and every subsequent year is about one percent, but this depends on the usage patterns and should not be used as a hard and fast rule. When using the BESS, it is important to follow all procedures recommended by the supplier to reduce degradation and protect the battery and work with the contractor to ensure these mitigation efforts are instituted. An owner should consult with the contractor to ensure they understand the degradation of their system and keep expectations in check based on the contractor's experience.

As detailed in Section 11.2 Monitoring of the BESS, BESS can possibly be monitored through the supplier’s phone application, or online monitoring platform. In addition to basic monitoring, some companies will provide data analytics for the BESS to describe more details on the system. With effective due diligence, a user will be able to monitor for sudden dips in performance and determine if there is an issue that requires an inspection. If the performance of the BESS has gone beyond the limitations specified in the warranty, the owner may be entitled to a replacement. Always read through the terms and conditions of the warranty, before making a claim with the supplier. Even if there is not a sudden dip in performance, it is recommended to schedule and perform an annual (once a year) check of the operating status and connection status of the BESS unit.

14.3 Moving BESS Units Between Buildings

Much like it is possible to move appliances or other heavy electrical equipment from one building to another, it is possible for a storage system to be moved. The entire system would have to be disconnected by a qualified installer, properly stored, transported to the new building, and reinstalled, in accordance with the manufacturer’s instructions. This can be a timely process and quite costly. In addition, there may be additional barriers preventing the system from being installed. If the product standards change and the BESS no longer meets the new standard, it cannot be reinstalled. Or, simply, the new building may not allow for the system to be installed on the premises. Therefore, while it is technically possible to move the battery storage system to a new building, the owner should check with the installer and/or the manufacturer before moving that the installer will be able to reinstall the system, and that the building will allow for the installation.

15. Proper Disposal at End-of-Life

End-of-Life (EOL) can be considered as two different scenarios for a BESS: either the system has degraded to a point where it is no longer financially viable to operate, or the cells within the battery packs have degraded to a point where they are unsafe to continue operating. The system owner must consider the need to decommission the system and to send components for proper disposal.

When a BESS reaches its EOL point, there is a higher chance of a safety issue occurring, and the system warranties and performance guarantees may no longer be available to the owner. The internal resistance of the cells, inside the battery packs and modules, has increased with the degradation that had occurred over its operating life. This increases the heat generation and lowers the round-trip efficiency (RTE). Increased heat generation may cause further harm to the battery and could increase the risk of a failure occurring (e.g., fire or explosion). It is advised that the owner should move to decommission the BESS, following the manufacturer's guidance, once it has reached its EOL.

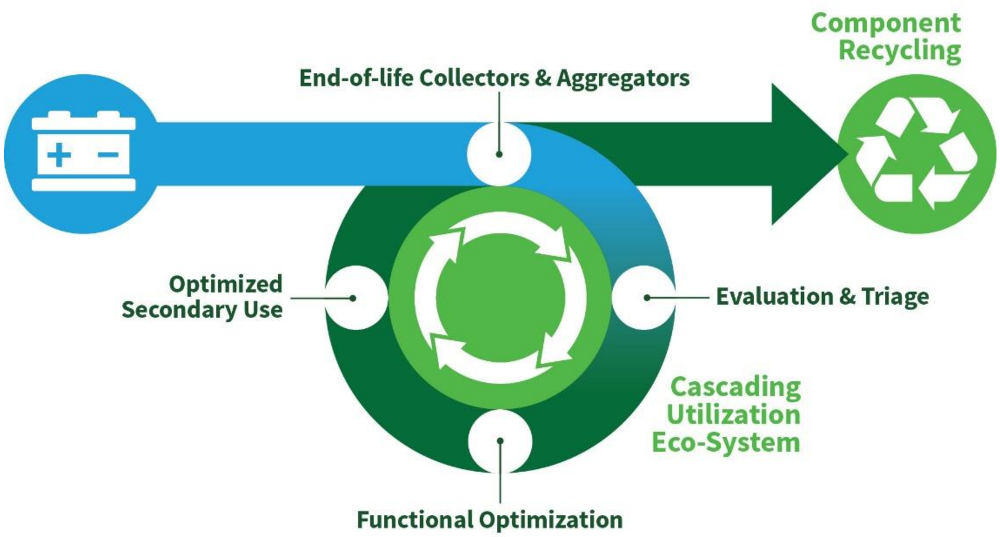

Figure 15-1: End-of-Life BESS Flowchart

15.1 Plans at End-of-Life

The owner is responsible for scheduling decommissioning activities and ensuring they are executed. After each yearly assessment of the battery life, a discussion on the remaining useful life of the BESS should be had with the installer. If any warranties still exist for the BESS, the options outlined within them should be explored first. After that, the installer can provide decommissioning and removal services for the system.

Only qualified professionals shall remove the BESS and its associated components, for replacement or for recycling at the end of the product's working life. To prevent damage to the product, and for their own safety, owners should not attempt to remove the battery and should contact the supplier, or other independent service providers for BESS removal. Before removal, the batteries shall be safely discharged to remove any remaining energy. Removal of the BESS will involve disconnection of the electrical cables and careful extraction of the equipment from its location. The qualified installer shall follow the steps detailed by the supplier to safely discharge the system and disconnect and remove the BESS from the building.

Batteries are considered hazardous waste and cannot simply be placed in the onsite garbage disposal. They need to be properly recycled at a qualified battery recycler. Currently British Columbia's Waste Management Recycling program does not take lithium-ion batteries greater than 5 kg. When first purchasing a BESS, the supplier should be asked whether they have a battery recycling program in place, and what the proper disposal procedures are. The owner, with assistance from a qualified installer, shall work with the supplier to ensure safe disposal of the removed BESS. The supplier will, often, have a program to take BESSs back to their own facility for recycling, or they will have a list of contacts with large-scale battery disposal companies that the installer can ship the owner's battery to. The installer shall follow all procedures provided by the supplier to ready the BESS for storage and transport.

15.1.1 Decommissioning Plan

Prior to decommissioning, the installer shall prepare a written decommissioning plan. Although it is the owner's responsibility to ensure there is a plan, it is best practice to have a knowledgeable and qualified agent to prepare the document on the owner's behalf. The plan shall include the following information:

- Overview of the decommissioning process for the specific BESS to be decommissioned.
- Description of roles and responsibilities for all personnel.
- Means and methods in the decommissioning plan submitted during the permitting process.
- BESS plans and specifications.
- Detailed descriptions of each activity to be conducted during the decommissioning process.
- Procedures to document the decommissioning of equipment.
- Guidelines and format for a decommissioning checklist, relevant operational testing, and a decommissioning report.
- Description of how surrounding areas and systems will be protected during decommissioning. Including, but not limited to means of egress, building penetrations, fire detection and suppression systems, and structural elements.

15.1.2 Decommissioning Process and Report

A permit will need to be acquired to perform the necessary decommissioning work. The decommissioning plan will be executed by the qualified electrical worker and the equipment decommissioned. Once complete a decommissioning report shall be prepared by the qualified agent to summarize the decommissioning process. The report shall include the final decommissioning plan, the results of the process, and any issues identified. The report shall be retained by the owner to provide upon request.

15.1.3 Replacing or refurbishing the BESS Units

With BESS units used for C&I tending to have energy capacity values greater than 50 kWh per unit, there is more flexibility in replacing battery packs in these systems. The larger systems tend to be constructed of modules that can be physically replaced on-site rather than needing to have the entire unit returned to the supplier. This is advantageous as the unit can remain in place, undergo the rework, and be operational in a much faster timespan than if the whole unit needed to be shipped away. Consult with the installer if the supplier offers a replacement program and the new modules are backwards compatible with the older system. Once again costs for a full system replacement versus a module replacement inside the BESS should be explored before proceeding with a full system decommissioning.

15.2 Cost Considerations for Disposal at EOL

Disposal costs for BESS units can be quite expensive, as it will require determination of the cost of removal at a future point in the asset’s life. It is important to develop an accurate scope of work as detailed in the Decommissioning Plan, and to establish a baseline for the associated fees.

It is becoming more common for contract language to specify that system decommissioning responsibilities, and their costs lie with the operations and maintenance provider or installer, even though the owner is liable for proper treatment of removed equipment. In the United States, various state agencies are encouraging or requiring the development of energy storage decommissioning plans at project inception, along with the establishment of decommissioning funds. These plans must include details about the estimated cost of decommissioning and plans for ensuring its funding, and contingency plans for removal of damaged batteries. Under such arrangements, the installer identified as responsible typically provides all decommissioning services (including restoration of the site to original state if required, and removal of the equipment). It is important to obtain from the installer a cost to decommission and remove the system.

With changes to the industry happening so rapidly, the decommissioning plan and costs are likely to evolve over time. It is recommended practice for the owner to negotiate the frequency of updates to the decommissioning plan. Updates to the plan three years before the end of operations of the project shall provide an accurate estimate of the decommissioning costs. If not already part of the contract for the system it is important to have money set aside for this eventuality, as the asset reaches its EOL, it will need to be removed.

15.2.1 *Approximate Decommissioning Costs*

Decommissioning costs for BESS can be significant and vary by battery type and local regulations. The costs to decommission a BESS will include labour and equipment to prepare the system for removal, shipping of the system to a recycler for offsite dismantling, and the cost of recycling the equipment. The first two costs will be based on the jurisdiction and the labour available to perform the work and remove the equipment.

There are approximations for the costs of recycling equipment. For C&I systems, various institutions have provided estimations of the costs of different aspects of the BESS units, utilizing the experience gained from different projects. Pacific Northwest National Laboratory (PNNL) publishes this information online (Lithium-ion Battery (LFP and NMC) | PNNL). Using this information, an approximation of the anticipated recycling costs can be determined. Table 15-1 shows the approximate recycling costs for a BESS for various sizes.

Table 15-1: Approximate Recycling Costs

Duration (hrs)	2	4	6	8
Recycling Costs [$/kwh] *	3.82	3.82	3.82	3.82

*Values converted from USD to CAD at a conversion rate of 1.44 CAD to USD (March 26, 2025, date of conversion).

As an example, if the owner plans to install a 4-hours BESS unit that is a one MW power capacity (4 MWh energy storage capacity), the approximate recycling costs per year would be approximately $15,260 per year.

BC Hydro
Power smart

Appendix A
Certifications for BESS

A.1 Required and Optional Certifications for BESS or BESS Components

Standard	Equipment	Required or Optional	Purpose
UL 1741	Inverter and Power Converter equipment	Required	Safety
UL 9540	Battery	Required	Safety
UL 9540A	Battery	Required	Fire Safety
UL 1943	Battery	Required	Safety
UL 1642	Battery Module	Required	Safety
CSA C22.2 No 107.1	Power Conversion Equipment	Required	Safety
FCC Part 15 Class B	Battery	Required	Emissions
IEEE 693-2005 (high)	Electrical Equipment	Optional	Seismic Design
NEMA 3R (or better)	Enclosure	Required	Safety
Hazardous material classification Class 9	Battery	Required	Hazard Control
IEEE 1547	Interconnection requirements of DER with Electric Power Systems	Required	Grid Code Compliance
IEEE 1547A	Amendment 1 to 1547- Abnormal Operating Performance Cat. III	Optional	Grid Code Compliance
UL 1741SA	Renewable Energy Inverters	Optional	Grid Code Compliance
UL 1741SB	Distributed Energy Resources	Optional	Grid Code Compliance
UL 1741PCS	Power Conversion System	Optional	Safety
UN38.3	Lithium Batteries	Required	Transport Safety
CSA C22.2 No. 9	Electric Luminaires	Optional	Safety
CSA C22.2 No. 330	PV rapid shutdown systems	Optional	Safety
UL 3741	PV Hazard control	Optional	Hazard Control
UL 1998	Programmable components	Optional	Reference Std
AC156	Non-Seismic shake	Optional	Evaluation Service
ICES 003	IT Equipment	Optional	
IEC60730-1 Annex H	Electronic Controls	Optional	Functional Safety
Environmental: RoHS Directive 2011/65/EU	Electronic and electrical equipment	Required	Hazard Control

Required – Minimum certifications to look for in a BESS system.

Optional – Some manufacturers might have some of these due to the different use cases they provide with their system.

Note that this list is not exhaustive and the certification of each system varies according to the BESS manufacturer. It is important to work with a trained professional to know which certifications are necessary for the intended use case of the BESS.