APIS GUIDE 03 · ENERGY

Battery energy storage for *industry.*

A sizing, safety and integration guide for battery storage on commercial and industrial sites — written for plant owners, energy managers and the people who have to approve the investment.

APIS · BATTERY ENERGY STORAGE (BESS)

29 pages · PDF · English
Issue v1.0 · 18 August 2026
apisgroup.net/guides-ebooks

ABOUT THIS GUIDE

Answer one question *before any other.*

What is the battery for? Not "storage", not "resilience", not "energy independence" — what specific job does it do, on this site, on a Tuesday in February? Almost every disappointing battery installation can be traced to that question never being answered precisely, because the answer determines the size, the chemistry, the location, the controls, the safety case and whether the investment makes sense at all.

A battery sized to shave a demand peak and a battery sized to ride through an outage are different machines. One needs high power for minutes; the other needs energy for hours. Buy the wrong one and it will work perfectly while failing to do the thing you bought it for.

This guide covers how to define the use case, how to size power and energy as the separate questions they are, what the load profile survey must capture, what a battery warranty actually promises, the fire and deflagration safety case that governs where the system can be put, and how it connects to the grid and to any PV already on site. It ends with a forty-point checklist you can take into a feasibility study or a tender.

> WHAT THIS GUIDE CANNOT TELL YOU, AND WHY
>
> The business case for storage depends on the tariff structure, the grid connection rules, the permitted revenue streams and the support schemes applicable where the site is — and those change, sometimes annually. **No figure in this guide is a tariff, a payback period or a rate of return**, because a number printed here would be wrong somewhere and out of date everywhere.
>
> What the guide does instead is tell you exactly which positions to establish, in writing, with your distribution system operator, your supplier and the regulator — and in what order — so that the commercial evaluation you build rests on something real. Section 08 sets those out.

Who this is written for

- Owners and energy managers of manufacturing plants, cold stores, logistics facilities and large commercial buildings
- Sites with existing rooftop or ground-mounted PV considering whether to add storage
- Sites with critical processes exposed to supply interruption or voltage disturbance
- Boards, banks and investors evaluating a storage proposal somebody else has prepared
- Consultants and contractors specifying or reviewing a system

What this guide is not

It is not a design document and does not replace a qualified electrical designer, a fire engineer or a competent grid connection specialist. It does not cover grid-scale storage connected at transmission voltage, domestic batteries, or the design of the battery equipment itself. It states no prices, no tariffs and no payback periods, and it recommends no manufacturer.

How to use it

Sections 01 to 03 are the definition stage — the use case, the sizing logic, and the data you need before anyone can size anything honestly. Sections 04 to 07 are the technical core: chemistry and degradation, safety, grid integration, and commissioning. Section 08 sets out what the commercial case rests on. If you are reviewing a proposal rather than preparing one, start at the checklist in Section 09.

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Document APS-GD-03, issue v1.0 of 18 August 2026. Prepared by the APIS Battery Energy Storage (BESS) Division.

SECTION 01

What is the battery *for?*

Five distinct jobs, each producing a different machine. Most disappointing installations are the result of buying for one and hoping for another.

A battery is not a general-purpose improvement to a site. It is a device that moves energy in time, and the value it creates depends entirely on which movement in time is worth money or worth avoiding on your particular site. Five use cases account for almost all commercial and industrial storage. They are not mutually exclusive, but they pull the design in different directions, and one of them must be primary.

1 · Peak shaving — reducing the maximum demand you are billed for

Many commercial and industrial tariffs charge for peak demand as well as for energy — a capacity or maximum-demand component, often set by the highest half-hour or quarter-hour in a billing period. A battery that discharges during those brief peaks reduces the recorded maximum and therefore the charge.

What it demands: high power for short durations, reliable detection of an emerging peak, and control fast enough to respond before the interval closes. Energy capacity can be modest. The critical dependency is the tariff — establish exactly how the demand charge is calculated before assuming anything.

2 · Self-consumption — using more of your own generation

A site with PV that exports at midday and imports in the evening is buying back what it just gave away, usually at a much worse price. Storage shifts that generation into the evening.

What it demands: energy capacity matched to the daily surplus, and moderate power. The critical dependency is the difference between the import price and whatever the exported energy earns — a difference that is set by regulation and can change.

3 · Backup and process continuity

Some processes fail expensively on interruption: a cold store losing a load, a batch process losing its charge, a production line whose restart takes hours. Storage can hold the site through short interruptions, or bridge to a generator.

What it demands: energy for the required ride-through duration, and — more importantly — a completely different electrical design. Backup requires the ability to disconnect from the grid and support the load independently, which means islanding capability, protection coordination and a clear definition of which circuits are supported. **A grid-following battery installed for peak shaving will not keep your site running in an outage** unless it was specified to do so.

4 · Power quality and process protection

Voltage dips, short interruptions and flicker cause more industrial losses than full outages do, and they are frequently blamed on equipment rather than on supply. A battery with a fast inverter can ride through disturbances that trip sensitive plant.

What it demands: very fast response and high power for very short periods. Energy capacity may be small. This use case is often the one that pays and is almost never the one that gets investigated, because the losses are recorded as machine faults rather than as supply events.

5 · Grid services and arbitrage

Where the market permits it, storage can earn by responding to system operator signals or by buying cheap and selling dear.

What it demands: market access, metering and telemetry to the operator's requirements, a qualified route to market, and a tolerance for cycling that shortens battery life. **This is the use case most dependent on rules that vary by country and change over time.** Establish that the route to market exists and is open to a site of your size before any of it enters a business case.

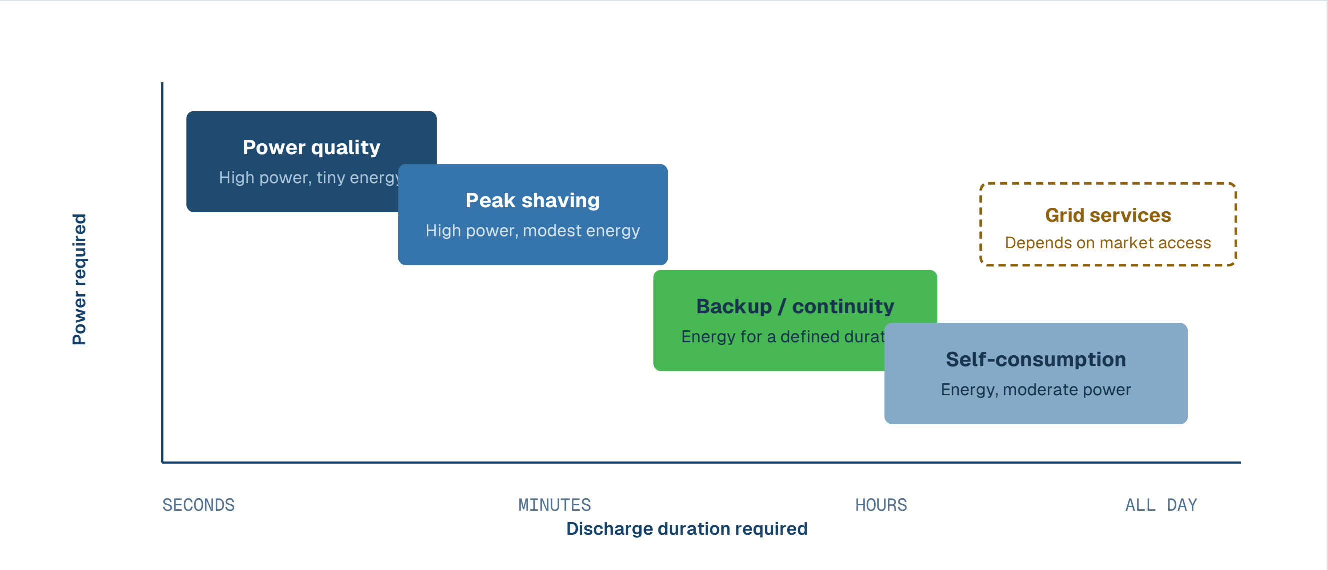

Figure 1.1 — The five use cases occupy different regions of the power-versus-duration plane. Positions are indicative of the relationship only, not of any specific sizing. A system designed for one region will serve the others poorly.

Stacking, and its limits

A single battery can serve more than one purpose, and vendors will emphasise this. It is genuinely possible — but only within limits that must be stated at design stage rather than assumed.

- **State of charge is a shared resource.** A battery held at high charge to provide backup is not available to absorb midday PV surplus. A battery discharged for self-consumption is not available for an evening demand peak. Every additional purpose constrains the others, and the control system must be told the priority order explicitly.
- **Cycling shortens life.** Revenue that comes from frequent charge and discharge consumes warranty throughput. See Section 04.
- **Backup is structural, not a setting.** If islanding capability was not in the electrical design, it cannot be added by changing the control strategy.

> WRITE DOWN THE PRIORITY ORDER, AND PUT IT IN THE CONTRACT
>
> If the system is to serve more than one purpose, state which purpose wins when they conflict, and under what conditions — for example: reserve a defined portion of capacity for backup at all times; shave peaks above a stated threshold; absorb surplus generation only with what remains. If that hierarchy is not written down before procurement, it will be decided by whoever configures the controller, and nobody will know it happened.

The screening question

Before engaging anyone: what would this battery have saved or earned, on this site, in each of the last twelve months, and from which specific line of which specific bill?

If that question cannot be answered from data you already hold, the first project is not a battery. It is the metering described in Section 03.

SECTION 02

Power and energy are *two different questions.*

Kilowatts and kilowatt-hours are sized separately, for different reasons, and confusing them is the most common technical error in a storage specification.

A battery system is described by two independent numbers, and a specification that gives only one has not specified anything.

Power — kW or MW	How fast the system can charge or discharge. Set principally by the inverter and the battery's permitted current. Determines how large a demand peak you can shave, how much load you can support in an outage, and how quickly you can respond to a disturbance.
Energy — kWh or MWh	How much the system can store. Set by the cells. Determines how long the system can sustain its output, how much daily PV surplus it can absorb, and how long a process can ride through.

The ratio between them — energy divided by power — gives the **duration**: how long the system can run at full output. A one-hour system and a four-hour system with the same power rating are very different investments, and only one of them will do a given job.

C-rate, and why it constrains the design

The relationship between power and energy is expressed as the C-rate: discharging a system at a rate that would empty it in one hour is 1C; in two hours, 0.5C; in fifteen minutes, 4C. Cells have limits on continuous and peak C-rate, and running near those limits generates heat, reduces round-trip efficiency and accelerates degradation.

The practical consequence is that a high-power, short-duration requirement — peak shaving or power quality — cannot always be met simply by buying a small battery with a large inverter. Either the cells must tolerate the C-rate, or more energy capacity must be installed than the application needs, purely to keep the current within limits. That is a legitimate design outcome and it should appear explicitly in the sizing rationale rather than as an unexplained increase in cost.

Usable energy is not nameplate energy

Several deductions sit between the nameplate figure and the energy you can actually use, and a specification must be explicit about which figure it refers to.

- **Depth of discharge limits.** Operating between defined state-of-charge bounds rather than from full to empty preserves life. The usable window is narrower than the nameplate.
- **Round-trip efficiency.** Energy is lost in conversion and in the cells. You put more in than you take out, and the difference appears on your import bill.
- **Auxiliary consumption.** Thermal management, controls and fire systems draw power continuously — including when the battery is idle. On a system that cycles rarely, the auxiliary load can consume a meaningful share of the benefit.
- **Degradation.** Capacity declines over life. A system sized to just meet the requirement on day one will fail to meet it in year seven. See Section 04.

THE SINGLE CLARIFICATION TO DEMAND FROM EVERY TENDERER

Is the quoted energy figure nameplate, beginning-of-life usable, or end-of-warranty usable — and at what temperature and C-rate? Two proposals quoting the same kWh can differ by a wide margin in what they will actually deliver in year ten. Require every tenderer to state the figure on the same defined basis, or the comparison is meaningless.

Sizing logic by use case

Use case	Power is set by	Energy is set by
Peak shaving	The gap between your measured peak and the target you want to hold	The duration of the peak events, and how many occur before there is time to recharge
Self-consumption	The maximum surplus generation, and the maximum evening load you want to cover	The typical daily surplus you want to capture — usually a shoulder-season day rather than the best summer day
Backup	The connected load of the circuits to be supported, including motor starting	The required ride-through duration, at that load, at end of warranty
Power quality	The full load to be protected, with the inverter's transient capability stated	Often small — but check the depth and duration of the disturbances you actually experience
Grid services	The product's requirements, if the market is accessible	The product's requirements, plus the cycling implication for warranty

Sizing for the peak you can afford, not the peak you have

For peak shaving in particular, the naive approach is to size for the largest peak in the record. That is almost always the wrong answer, because the largest peak may occur once a year and the cost of covering it fully is disproportionate.

The better method is to model the saving against a range of target thresholds, and find the point at which additional battery capacity stops paying for itself. That produces a smaller system that captures most of the benefit — and it requires the interval data described in the next section. Any proposal that arrives at a size without showing that curve has skipped the analysis.

SECTION 03

The load profile *survey.*

Nothing in this guide can be sized honestly without it, and most sites discover they do not have the data at the point they need it.

A monthly electricity bill tells you almost nothing useful for storage. It gives totals; what storage design needs is shape. Two sites consuming identical annual energy can have completely different peaks, different daily patterns and completely different storage cases.

What data is needed

Interval consumption	Active power at the metering interval used for billing — commonly quarter-hourly or half-hourly. This is the foundational dataset and there is no substitute for it
Period covered	A full twelve months, to capture seasonal variation, shutdowns and the annual peak. Shorter periods systematically mislead
Reactive power	Where the tariff includes a power factor or reactive component, because an inverter may be able to address it as a secondary benefit
Existing generation output	At the same interval, if PV or CHP is installed, together with what was exported
Bills for the same period	Every line, not the totals — the storage case is built from specific charges, and you must be able to point at the ones that change
Interruption and disturbance record	Dates, durations and, if known, the production consequence. Usually absent, and usually the most valuable dataset nobody has
Planned changes	New plant, expansion, electrification of process or fleet, planned PV. Sizing for today's profile when a known change is coming is a wasted exercise

IF YOU DO NOT HAVE INTERVAL DATA, START THERE

Many sites in the region have billing metering that records totals rather than intervals, or have the data held by the supplier in a form nobody has requested. Two routes: ask the supplier or the distribution operator for the interval data they already hold, which is often available and rarely requested; or install monitoring at the main incomer and run it for a year.

A year of monitoring feels like a delay. It is considerably cheaper than a battery sized from assumptions — and the monitoring is useful permanently, because it is also how you will verify that the battery performed once it is installed.

What to look for in the data

- **The shape of the peaks.** Are they brief spikes from motor starts and simultaneous plant, or broad plateaus lasting hours? Brief spikes are cheap to shave; broad plateaus are expensive.
- **How often the annual maximum is approached.** If the peak is approached weekly, shaving it is straightforward to justify. If it occurred once, in one exceptional hour, sizing for it is poor value.

- **Whether peaks coincide with generation.** A site whose peaks occur at midday alongside its PV has a different problem from one peaking after dark.
- **Recharge windows.** The battery has to refill between events. A site with consecutive peak periods and no low-demand window between them constrains the design significantly.
- **Baseload versus process load.** The split determines what a backup system would have to support, and often reveals that only a fraction of the site genuinely needs protection.
- **Weekends, holidays and shutdowns.** Extended idle periods affect both the business case and the battery's state-of-charge management.

The survey is more than data

Alongside the electrical record, the site survey must establish the physical and organisational facts that determine whether a system can be installed at all:

- **Available space**, and whether it is outdoors or inside a building — Section 05 explains why this is the single most consequential siting decision
- **Distance and route to the point of connection**, and the capacity of the existing switchgear and cabling
- **Existing protection arrangement and earthing**, and whether the switchgear has spare capacity and fault rating headroom
- **Access for delivery and for replacement** — battery enclosures are heavy and are eventually removed
- **Separation distances** available from buildings, boundaries, occupied areas, other hazardous storage and escape routes
- **Fire service access** and the availability of water
- **Ambient conditions** — temperature extremes, flooding, dust, salt, seismic requirements
- **Who will operate it**, what competence they hold, and who is called at three in the morning

> SURVEY OUTPUTS TO CARRY INTO THE DESIGN
>
> - Twelve months of interval data, cleaned, with gaps identified
> - The peak-threshold curve — saving against target, across a range of thresholds
> - Bill decomposition identifying exactly which charges a battery would affect
> - Stated primary use case and the priority order for any secondary ones
> - Siting options with separation distances and access assessed for each
> - Point of connection, with existing switchgear capacity and fault level confirmed
> - Register of planned site changes within the system's design life

SECTION 04

Chemistry, degradation and what a *warranty promises.*

Batteries wear out in two ways at once, and the warranty is a commercial document describing how much of that wear the supplier accepts.

The chemistry choice

Stationary commercial and industrial storage is dominated by lithium-ion, within which two families account for most installations.

Family	Characteristics	Consequence for a C&I site
Lithium iron phosphate — LFP	Lower energy density; greater thermal and chemical stability; typically long cycle life; no cobalt	Now the default for stationary storage where space is not the binding constraint. The stability advantage is directly relevant to the safety case in Section 05
Nickel manganese cobalt — NMC and related	Higher energy density; more energy in the same volume and mass; lower thermal stability than LFP	Chosen where space or weight is constrained. The higher energy density has direct implications for fire separation and the safety case

Other chemistries exist and some are well suited to particular duties — flow batteries for very long durations, sodium-ion as an emerging option, and lead-acid still present in short-duration backup. For a general C&I installation the practical choice is usually between LFP and NMC, and it should be made explicitly, on stated grounds, rather than inherited from whatever the supplier stocks.

> ASK WHY, NOT WHAT
>
> The right question to a supplier is not "which chemistry do you offer" but **"why is this chemistry right for this duty, on this site, given the space available and the fire strategy"**. A supplier who cannot answer that in engineering terms is selling a product rather than designing a system.

Two kinds of degradation

Capacity declines through two independent mechanisms, and a warranty must address both.

- **Cycle ageing** — wear from charging and discharging. Driven by the number of cycles, the depth of each, and the rate. A system that cycles twice daily ages faster than one that cycles twice weekly, regardless of the calendar.
- **Calendar ageing** — wear that occurs with time regardless of use, driven principally by temperature and by the state of charge at which the battery is held. A battery sitting idle at high charge in a hot room is degrading while doing nothing.

The practical consequences are worth stating plainly, because they shape the design:

1. **Temperature management is not a comfort feature.** It is the principal determinant of calendar life. An enclosure with inadequate cooling in a hot climate will lose capacity faster than the model predicted, and the model is what the warranty was priced on.

2. **Holding a high state of charge for backup has a cost.** A battery reserved at full charge for an outage that rarely comes is ageing continuously. This is an argument for reserving the minimum genuinely required, not the maximum that feels safe.
3. **Revenue from cycling consumes warranty.** Grid services and arbitrage produce income and consume throughput. Whether the trade is worthwhile is an arithmetic question, and it should be answered before the contract rather than discovered in year four.

What a warranty actually says

Battery warranties are frequently presented as a headline number of years. The number of years is the least informative part of the document. Read for the following, and require every tenderer to state each one on the same basis:

Term	What to establish
Retained capacity at end of term	The percentage of original usable capacity guaranteed at the end of the warranty period. This, not the year count, is the substance of the promise
Throughput limit	Total energy that may be cycled through the system, or a maximum number of cycles, over the term. Whichever limit is reached first usually ends the warranty — so a heavily cycled system may exhaust its warranty years early
Operating envelope	Temperature range, state-of-charge limits, C-rate limits, humidity. Operation outside the envelope voids cover, and it is the enclosure and the thermal design that keep you inside it
Measurement method	How retained capacity will be demonstrated in a dispute, by whom, at whose cost, and using what test. A warranty with no agreed measurement method is difficult to enforce
Remedy	Repair, replacement of modules, or augmentation with additional capacity. Whether labour, transport and disposal are included. Whether replacement modules are new or refurbished
Availability and performance guarantees	Separate from capacity. Whether the supplier guarantees system availability, and what happens if it is not met
Conditions and exclusions	Required maintenance, required monitoring, required firmware updates, connectivity obligations. Some warranties are void if the supplier loses remote access to the system
Who stands behind it	The cell manufacturer, the system integrator, or the local installer — and what happens if that entity ceases trading. A twenty-year promise from a company without a twenty-year balance sheet is a different product

SIZE FOR END OF WARRANTY, NOT FOR DAY ONE

A system that exactly meets the requirement when commissioned will fail to meet it well before the end of its life. Define the duty the system must perform, decide the year in which it must still perform it, and size on the guaranteed retained capacity in that year — or plan and price an augmentation, with the space, the connection capacity and the compatibility provided for at the outset.

Augmentation planned at design stage is straightforward. Augmentation discovered in year eight, on a site with no space and a full switchboard, generally is not.

End of life

A battery installation has a disposal obligation, and it should appear in the evaluation rather than be left to the future. Establish who is responsible for removal and recycling, what it is expected to cost, whether the supplier operates a take-back arrangement, and what the applicable waste regulations require at the site's location. For an institutional owner with reporting obligations, this belongs in the paperwork from the beginning.

SECTION 05

Safety — the section nobody reads *until it matters.*

The fire behaviour of a lithium battery installation is different from anything else on an industrial site, and it governs where the system can go.

This is the most important section in the guide, and it is the one most often reduced to a line in a specification saying that the system shall comply with applicable standards. It determines siting, separation, building works, detection, suppression, insurance, permitting and emergency response — and every one of those is cheap to arrange at design stage and extremely expensive to retrofit.

What actually happens in a lithium battery fire

A cell can be driven into **thermal runaway** by internal defect, mechanical damage, overcharge, over-discharge, external heating or a cooling failure. Once it starts, the reaction is self-sustaining: the cell generates its own heat, and it does not require external oxygen to continue.

Three characteristics follow, and each has a design consequence:

1. **Gas is released before flame.** A cell in early runaway vents a mixture of flammable and toxic gases, often minutes before there is anything to see or smell. This is the single most useful fact in the whole safety design, because it means detection is possible before the event becomes a fire.
2. **Accumulated gas can deflagrate.** In an enclosed space, vented gas accumulates and can ignite explosively. **The explosion hazard, not the fire, is usually the dominant risk to people and to structure** — and it is the reason that ventilation and explosion protection are central rather than incidental.
3. **Runaway propagates.** Heat from one cell drives its neighbours into the same condition. Whether propagation is arrested within a module, a rack or an enclosure is a property of the product's design, and it is demonstrated by large-scale fire testing rather than asserted.

> CONVENTIONAL FIRE SUPPRESSION DOES NOT STOP THERMAL RUNAWAY
>
> Gaseous clean-agent systems extinguish flame by removing oxygen or interrupting combustion chemistry. Thermal runaway is an internal reaction that supplies its own oxidiser, so removing the room's oxygen does not arrest it. The agent discharges, the flame goes out, the reaction continues, and the fire re-establishes.
>
> The accepted approach is **cooling** — large quantities of water, applied for a long time, to remove heat from cells not yet in runaway and prevent propagation. This has immediate design consequences: water supply, drainage, containment of contaminated firewater, and structural loading. A clean-agent system specified alone, without a cooling strategy, is a solution to the wrong problem.

The siting decision

Outdoors, in a purpose-built enclosure, well separated from everything else, is the straightforward answer. Everything else is harder.

An outdoor containerised installation with adequate separation from buildings, boundaries, occupied areas and other hazards resolves most of the safety design by geometry. The gas disperses, the deflagration risk to occupied structures is limited by distance, and firefighting access is straightforward.

Placing the system inside a building — particularly an occupied or high-value one — converts every one of those into an engineering problem requiring active measures: fire-rated separating construction, explosion protection, mechanical ventilation, detection, cooling, containment of firewater, protection of escape routes, and a considerably more demanding conversation with the authorities and the insurer.

Both are legitimate. They are not comparable on cost, and a proposal that assumes indoor siting without pricing what indoor siting requires is not complete.

The safety case, layer by layer

Layer	What it must address
Product-level protection	Cell and module design, battery management system, over-voltage, over-current, over-temperature and over-discharge protection, and demonstrated propagation behaviour from large-scale fire testing
Siting and separation	Distances to buildings, boundaries, occupied areas, escape routes, other hazardous storage, and between enclosures. These should be justified by the product's fire test data, not chosen by eye
Construction	Fire resistance of separating elements, structural behaviour under fire, protection of escape routes, and — where indoors — deflagration venting or explosion prevention
Ventilation	Sized and configured to prevent accumulation of flammable gas. This is an explosion protection measure and it is central rather than incidental
Detection	Off-gas detection, giving warning before smoke or heat detection would respond, interlocked to shut down, isolate and ventilate
Suppression and cooling	Water supply of adequate flow and duration, application arrangement, drainage and containment of contaminated firewater
Isolation and shutdown	Clearly marked, accessible means to isolate — including where the isolation point must be reachable when the enclosure cannot be approached
Emergency response	A plan agreed in advance with the fire service, site information, an exclusion zone, and guidance on stranded energy and re-ignition after the event appears over

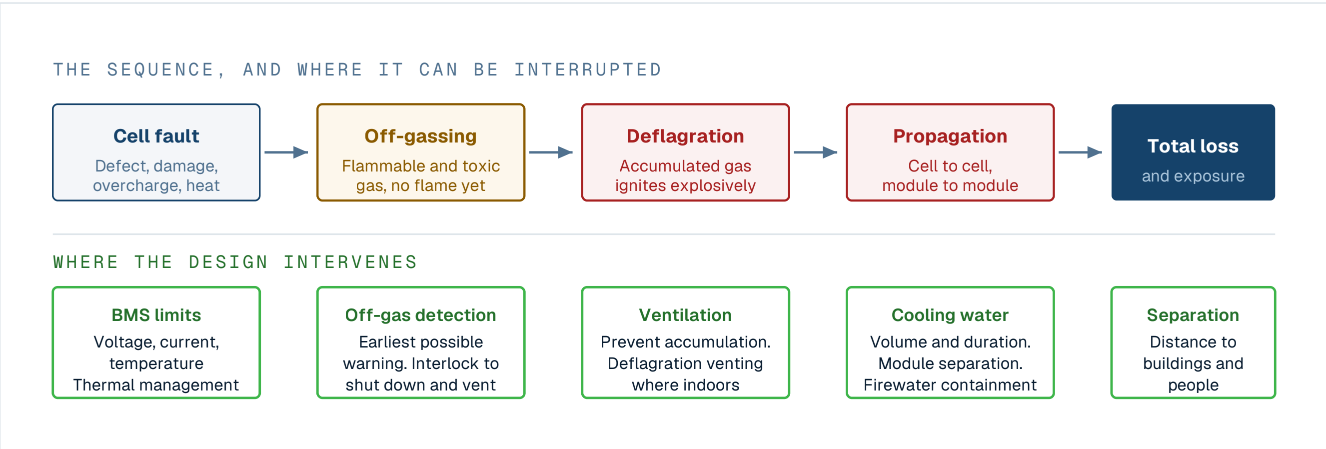

Figure 5.1 — Each stage of the sequence has a corresponding design measure. Off-gas detection is the earliest and cheapest intervention; separation is the last and the most reliable. The specific measures required for any installation must come from the applicable standards and a competent fire engineering assessment.

Fire test evidence, and why to ask for it

Separation distances and installation arrangements should be justified by evidence of how the specific product behaves in a fire, obtained from large-scale testing to a recognised method, rather than by general assumption. Ask every tenderer for the test report for the product being offered — not for a similar product, not for an earlier version, and not for the cell alone when the unit being installed is a rack or an enclosure.

Two further questions worth asking, because the answers are revealing: has this exact configuration been tested, and what did the test show about propagation between units at the separation distance proposed?

The conversations to have early

- **The fire service.** They will attend if something happens, and their tactical position on lithium battery fires may constrain your siting more than any standard does. Engage before the design is fixed, not at the point of approval.
- **The insurer.** Insurers hold specific requirements for battery installations, and they can be more demanding than the applicable standards. Discovering an insurer requirement after installation is expensive; discovering that cover is unavailable is worse.
- **The authority responsible for permitting** at the site's location, whose requirements govern.
- **Your own people.** Who is trained, what the evacuation arrangement is, what happens on an alarm at night, and who has the authority to isolate.

> STRANDED ENERGY AND RE-IGNITION
>
> After an incident, a damaged battery may retain substantial stored energy in cells that cannot be safely discharged, and re-ignition hours or days later is a documented behaviour. The emergency plan must cover the period after the fire appears to be out: who controls the exclusion zone, for how long, who assesses the installation, and who removes it. This is the part of the plan that is invariably missing.

SECTION 06

Grid connection *and integration.*

The system operator's requirements govern, they take time, and they are almost always underestimated in the programme.

A battery is a generator as far as the network is concerned, and in most jurisdictions it is treated accordingly. That means an application, a technical assessment, protection requirements, witnessed commissioning, and a connection agreement — each with its own timescale.

> START THE CONNECTION PROCESS BEFORE YOU FINISH THE DESIGN
>
> The grid connection application is routinely the longest lead item on a storage project and it is routinely started last, after the technical design is settled. The operator's response may constrain the export limit, the protection arrangement, the metering, or the size of the system itself — any of which sends the design back. Apply early, with a defined but not finalised proposal, and let the operator's answer inform the design rather than contradict it.

What to establish with the operator

- **Whether export is permitted at all**, and if so up to what limit. Many C&I storage systems are configured for zero export, which is a straightforward technical arrangement but must be designed in and demonstrated.
- **The protection requirements** — the settings, the required functions, and whether an interface protection relay of a specified type is required.
- **Anti-islanding and its interaction with any backup function.** These pull in opposite directions: the network requires the system to disconnect on loss of supply, while backup requires it to continue supplying the site. Both are achievable together, through a properly designed and clearly demarcated islanding arrangement — but it must be designed and agreed, not assumed.
- **Metering requirements**, including whether separate metering of the storage system is required and who supplies it.
- **Telemetry and control**, if the operator requires visibility or the ability to curtail.
- **Fault level contribution**, and whether the existing switchgear remains adequately rated with the inverter connected.
- **Power quality requirements** — harmonics, flicker and voltage regulation limits at the point of connection.
- **Witnessing and commissioning** — what the operator will witness, what notice is required, and what documentation must be submitted before energisation.

Coupling with existing PV

Where PV is already installed or planned, the battery can be connected in two fundamentally different ways, and the choice is usually made by whichever is easier to retrofit rather than by analysis.

Arrangement	How it works	Trade-offs
AC-coupled	The battery has its own inverter and connects on the AC side, alongside the existing PV inverter. The two systems are electrically independent	The natural choice for retrofit — the existing PV installation is untouched, and the battery can be sized independently. Energy from PV to battery passes through two conversions, so round-trip efficiency is slightly lower
DC-coupled	The battery connects on the DC side, sharing a hybrid inverter with the PV array	Fewer conversions, so marginally better efficiency for PV charging, and it can capture generation clipped by an undersized inverter. But it constrains inverter choice, ties the two systems together for maintenance and warranty, and is usually impractical as a retrofit to an existing PV installation

For a retrofit to existing PV, AC coupling is normally the practical answer. For a new combined installation, both should be evaluated — but the evaluation must include the maintenance and warranty consequences of tying the two systems together, not only the efficiency comparison.

Controls and the energy management system

The energy management system decides when the battery charges and discharges, and it is what turns the equipment into a result. Specify it as carefully as the hardware.

- **The control strategy for the primary use case**, stated explicitly — for peak shaving, how a peak is predicted and at what threshold the system acts; for self-consumption, how surplus is identified.
- **The priority hierarchy** between use cases, from Section 01, implemented and documented.
- **Measurement inputs** — where the system measures site demand, at what interval, and what happens if that measurement is lost.
- **Behaviour on communications failure.** A safe, defined default, not an undefined one.
- **Interfaces** to any existing building management or SCADA system, with the protocol and the data points specified.
- **Cybersecurity.** A grid-connected asset with remote access is an exposure. Establish who has remote access, by what route, with what authentication, and what the supplier is permitted to do remotely without notifying you. Where the supplier's warranty requires permanent connectivity, that obligation and its security implications should be understood before signature rather than after.
- **Data ownership.** Who owns the operational data, who can access it, and whether you can extract it if you change service provider.

> THE QUESTION THAT EXPOSES A WEAK PROPOSAL
>
> **"Show me, from my own interval data, what your control strategy would have done in each of the last twelve months, and what it would have saved on each specific line of my bill."**
>
> A serious proposal can answer this, because the analysis is how the system was sized. A proposal that cannot is quoting equipment rather than offering a result.

SECTION 07

Commissioning, monitoring *and operation.*

A battery that is energised has not been proved. What it does on an ordinary Tuesday is the only test that matters.

Storage differs from most plant in that its value is entirely a matter of behaviour. A chiller either produces cold water or it does not. A battery can be fully functional, fully charged and completely failing to deliver the benefit it was bought for, because the control strategy is wrong, the threshold is set badly, or the measurement input is reading the wrong circuit. None of that is visible from the fact that it works.

The commissioning sequence

1. **Electrical installation verification —** inspection and testing of the installation to the applicable standards, before energisation.
2. **Protection settings verified** against the operator's requirements, with the settings recorded as applied.
3. **Safety systems proved —** off-gas detection, interlocks, ventilation, shutdown, isolation, alarms to whoever receives them. Each function tested individually and as a chain, with results recorded.
4. **Thermal management proved** at representative load, with cell temperatures recorded across the system. Temperature uniformity matters as much as absolute temperature — a system with hot spots will age unevenly.
5. **Capacity test —** a full charge and discharge under controlled conditions, measuring the usable energy actually delivered. This is the baseline against which all future degradation is measured, and without it a warranty claim in year eight has no starting point.
6. **Round-trip efficiency measured** at the same time, including auxiliary consumption.
7. **Grid connection witnessed** to the operator's requirements, with anti-islanding and any agreed export limitation demonstrated.
8. **Control strategy proved against real events —** the system demonstrated responding to an actual demand peak, an actual surplus, or a simulated one where the real condition cannot be arranged.
9. **Islanding transfer demonstrated**, where backup is part of the scope, with the supported load actually connected — including motor starting.
10. **Training and handover**, including the emergency response arrangements from Section 05.

> THE CAPACITY TEST IS NOT OPTIONAL
>
> It is the only measurement that establishes what you actually received, and it is the reference point for every future performance discussion. It takes time, it requires the site to accommodate a full charge and discharge, and it is the item most frequently dropped when the programme is tight. Make it a contractual hold point before final payment.

What to monitor, permanently

Commissioning proves the system on one day. Monitoring proves it every day, and it is what turns a warranty into something enforceable.

Metric	Why it matters
Energy charged and discharged	The basis of throughput against the warranty limit, and of any performance calculation
Site peak demand, before and after	The direct measure of whether peak shaving is working. Compare against the pre-installation baseline from Section 03
State of charge over time	Reveals whether the control strategy is behaving as intended and whether reserved capacity is genuinely being held
Cell and module temperatures	The leading indicator of both degradation and of a developing fault
Round-trip efficiency	Declines as the system ages, and a sudden change indicates a problem
Auxiliary consumption	Frequently unmeasured and frequently larger than assumed, particularly on a system that cycles rarely
Availability	Hours unavailable, and why. Required for any availability guarantee to mean anything
Measured capacity, periodically	An annual or biennial capacity test against the commissioning baseline. This is the evidence for a warranty claim, and it must be gathered before it is needed

The first year

Three things are worth doing in the first year, and they are worth more than anything done later:

1. **Verify the saving against the bill, monthly.** Not the supplier's dashboard — the actual invoice, compared against the baseline. Dashboards report what the system did; invoices report what it was worth. They diverge more often than anyone expects, usually because a tariff detail was misunderstood at design stage.
2. **Review the thresholds after one full seasonal cycle.** A peak shaving threshold set from a year of historical data will need adjustment once the site's behaviour with a battery present is known — the load pattern itself changes.
3. **Run the capacity test at the end of the first year**, while the contractor is still on risk and any shortfall is straightforward to pursue.

Maintenance and the operating obligation

- **Scheduled maintenance** to the supplier's requirements, because failure to perform it commonly voids the warranty. Establish the scope, the frequency and who does it before signature.
- **Filter and cooling system maintenance** — the most common cause of temperature-related degradation is a neglected cooling system, and it is entirely preventable.
- **Safety system testing** at defined intervals, with records.
- **Firmware and software updates** — who applies them, with what testing, and what happens if an update changes the system's behaviour.
- **Spares and response times** — what is held, where, and what the contracted response time is for a fault. For a system supporting a critical process, this is a material term.

- **Competence —** who on site is trained and authorised to isolate, to respond to an alarm, and to escalate. Battery systems fail rarely, which means the response is rarely practised.

SECTION 08

What the business case *rests on.*

This section states no numbers. It states the positions you must establish before any number you are shown means anything.

The commercial case for storage is built almost entirely from local conditions: the tariff, the grid rules, the permitted revenue streams and whatever support schemes apply. Those vary by country, they are revised, and a figure printed in a guide would mislead. What is stable is the list of things that must be established, and the order to establish them in.

Establish these, in writing, before evaluating anything

Position	From	Why it decides the case
How the demand or capacity charge is calculated	Supplier and tariff document	The measurement interval, the reset period and whether it is based on the annual or monthly maximum determine whether peak shaving works at all and how much it is worth
The import price structure across the day	Supplier	Whether time-of-use differentials exist, and how large they are, determines whether shifting energy in time has value
What exported energy earns, and whether export is permitted	Supplier and DSO	The gap between import price and export value is the entire self-consumption case
Whether storage may participate in any market or service	Regulator, system operator	Grid services and arbitrage are only available where the rules permit a site of your type and size to participate, through a defined route
Grid connection conditions and any export limit	DSO	Constrains the system size and the achievable revenue, and is the longest lead item
Applicable support schemes, grants or tax treatment	Relevant authority	Can be decisive, and typically carries conditions and deadlines that shape the programme
Cost of the interruptions you actually experience	Your own production records	The backup and power quality case rests on this, and almost nobody has quantified it
Insurer requirements and premium effect	Insurer	Can add cost, can constrain siting, and can in principle make an installation uninsurable

REGULATORY CONDITIONS CHANGE — BUILD THE CASE SO IT SURVIVES THAT

A business case that depends entirely on a single revenue stream defined by current regulation is fragile, because the regulation can be revised within the asset's life. A case built primarily on avoided demand charges and self-consumption, with market revenue treated as upside rather than as the foundation, is considerably more robust.

Test every case against a scenario in which the most favourable regulatory element is withdrawn. If the project only works in the favourable case, that is not a reason to abandon it — but it is the risk, and it belongs in front of whoever approves the investment rather than in a footnote.

The cost structure

Battery system	Cells, enclosure, thermal management, battery management system, fire and gas detection
Power conversion	Inverter, transformer where required, protection, switchgear
Controls	Energy management system, metering, communications, integration with existing systems
Civil and siting	Foundations, hardstanding, access, bunding, drainage, security fencing, separation works
Electrical connection	Cabling, switchgear modification or replacement, earthing, protection relays
Safety measures	Ventilation, detection, water supply, firewater containment, fire-rated construction where indoors
Grid connection	Application, assessment, any reinforcement required, witnessing
Design, permitting and fire engineering	Including the fire engineering assessment, which is not optional and is often omitted from budget proposals
Recurring	Maintenance, monitoring, insurance, auxiliary energy consumption, software or service subscriptions
End of life	Removal, transport and recycling

How to present it, if it needs approving

- **State the primary use case first**, and show the benefit attributable to it alone. If the project only works when every secondary benefit is stacked, say so plainly.
- **Show the sizing curve** — benefit against system size — rather than a single point. It demonstrates that the size was chosen rather than proposed.
- **Use end-of-warranty capacity** in the later years of the model, not nameplate throughout.
- **Include auxiliary consumption and round-trip losses** as costs. They are frequently omitted and they are not small.
- **Include the fire engineering, the insurer's requirements and the end-of-life provision.** A proposal without them is not a comparison, and their absence is the quickest way to identify a proposal that has not been thought through.

- **Test against a range of energy prices** rather than presenting a single figure that depends on a forecast nobody can make.
- **State the regulatory dependency explicitly**, with the scenario in which it is withdrawn.

On savings claims generally. Any percentage saving or payback period quoted for storage depends on the site, the tariff, the load profile and the regulatory position. A figure quoted without twelve months of your own interval data behind it is marketing, not engineering. Establish the baseline first; everything after it can then be evaluated honestly.

SECTION 09

The forty-point *checklist.*

Take this into your feasibility study or your tender. If every box can be ticked before contract, most of what this guide describes will not happen to you.

A · DEFINITION

- [ ] The primary use case is stated in one sentence, naming the specific charge or risk it addresses
- [ ] Secondary use cases are listed, with an explicit priority order for when they conflict
- [ ] Any backup requirement is identified at this stage, because it is structural rather than a setting
- [ ] The circuits to be supported in an outage are defined, if backup is in scope
- [ ] The question "what would this have saved in each of the last twelve months" can be answered from data held

B · DATA AND SURVEY

- [ ] Twelve months of interval consumption data obtained at the billing interval
- [ ] Existing generation output and export recorded at the same interval
- [ ] Every line of the bills for the same period obtained, not the totals
- [ ] Interruption and disturbance record compiled, with production consequence where known
- [ ] Planned site changes within the design life registered
- [ ] Siting options assessed, indoor and outdoor, with separation distances available for each
- [ ] Point of connection identified, with switchgear capacity and fault level confirmed
- [ ] Delivery and future removal access route confirmed
- [ ] Ambient conditions assessed — temperature extremes, flooding, dust, seismic

C · SIZING

- [ ] Power and energy stated separately, with the resulting duration stated
- [ ] C-rate within the cells' continuous and peak limits, with the limits stated
- [ ] Energy figure defined as nameplate, beginning-of-life usable, or end-of-warranty usable — on the same basis from every tenderer
- [ ] Round-trip efficiency and auxiliary consumption stated and included in the model
- [ ] Sizing curve produced — benefit against size — rather than a single proposed figure
- [ ] Sized on guaranteed retained capacity in the year the duty must still be performed
- [ ] Augmentation planned, with space, connection capacity and compatibility provided for

D · CHEMISTRY AND WARRANTY

- [ ] Chemistry chosen on stated grounds, with the fire strategy implication addressed
- [ ] Retained capacity at end of term stated, not only the number of years
- [ ] Throughput or cycle limit stated, and checked against the intended duty cycle
- [ ] Operating envelope stated, and the thermal design shown to keep the system inside it
- [ ] Measurement method for a capacity dispute agreed, with cost responsibility
- [ ] Remedy defined — repair, replacement or augmentation, and what is included
- [ ] Warranty conditions reviewed, including any permanent connectivity obligation
- [ ] Entity standing behind the warranty identified, with its covenant considered

E · SAFETY

- [ ] Large-scale fire test report obtained for the exact product and configuration offered
- [ ] Separation distances justified by that test evidence, not chosen by eye
- [ ] Off-gas detection specified, interlocked to shutdown, isolation and ventilation
- [ ] Ventilation and, where indoors, explosion protection designed as a primary measure
- [ ] Cooling water supply, application, drainage and firewater containment specified
- [ ] Fire service, insurer and permitting authority engaged before the design is fixed
- [ ] Emergency plan covers the period after the fire — exclusion zone, stranded energy, re-ignition, removal

F · CONNECTION, CONTROLS AND COMMISSIONING

- [ ] Grid connection application submitted early, before the design is finalised
- [ ] Anti-islanding and any backup islanding arrangement designed together and agreed with the operator
- [ ] Control strategy, priority hierarchy, failure defaults, remote access and data ownership all specified
- [ ] Commissioning capacity test made a contractual hold point, with the result as the degradation baseline

Readiness sign-off

Complete and retain with the feasibility study or the tender documents.

STORAGE PROJECT READINESS SIGN-OFF

Item	Name and role	Date and signature
Site and point of connection		
Primary use case, in one sentence		
Interval data obtained and analysed by		
Fire engineering assessment by		
Grid connection application submitted		
Insurer position confirmed		
Checklist points 1–40 confirmed		
Outstanding items listed and owned		
Released for tender by		

IF YOU CAN ONLY DO THREE THINGS

One. Get twelve months of interval data before anyone sizes anything. If you do not have it, that is the first project.
Two. Settle the siting and fire strategy before the equipment is selected, because it governs both — and engage the fire service and the insurer while the design can still change.
Three. Require the capacity test at commissioning as a hold point, and repeat it at the end of the first year while the contractor is still on risk.

REFERENCE

Standards referred to *in this guide.*

Listed by number and subject so that you can obtain and read them. Confirm the current edition and the applicable national adoption before citing any of them.

STANDARDS REGISTER

Reference	Subject
IEC 62933 series	Electrical energy storage systems — terminology, unit parameters, planning, and safety requirements for grid-integrated systems
IEC 62619	Safety requirements for secondary lithium cells and batteries for use in industrial applications
IEC 63056	Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems
IEC 62485 series	Safety requirements for secondary batteries and battery installations
IEC 62477-1	Safety requirements for power electronic converter systems and equipment
UL 9540	Energy storage systems and equipment — system-level safety standard, widely referenced internationally
UL 9540A	Test method for evaluating thermal runaway fire propagation in battery energy storage systems — the source of the large-scale fire test evidence discussed in Section 05
NFPA 855	Standard for the installation of stationary energy storage systems — siting, separation, detection, suppression and emergency response
NFPA 68 · NFPA 69	Deflagration venting, and explosion prevention systems — referenced where enclosed installations require explosion protection
EN 50549 series	Requirements for generating plants to be connected in parallel with distribution networks, at low voltage and at medium voltage
HD 60364 / IEC 60364 series	Low-voltage electrical installations — design, erection, verification and testing
IEC 61000 series	Electromagnetic compatibility — emission and immunity limits relevant at the point of connection
IEC 62443 series	Security for industrial automation and control systems — relevant to the energy management system and remote access
UN 38.3	Transport testing requirements for lithium batteries — relevant to delivery and to any return of modules
ISO 50001	Energy management systems — relevant where the site operates a formal energy programme

HOW TO USE THIS REGISTER — AND WHAT GOVERNS ABOVE IT

Standards are revised, withdrawn and superseded. Verify the current edition with the national standards body applicable to your project, and confirm that the clause you intend to rely on still says what you think it says. Nothing in this guide should be relied upon as a statement of the content of any standard.

For a storage installation specifically, the requirements of the distribution system operator, the authority responsible for permitting at the site's location, and the insurer govern above all of the above. Where they differ from anything in this guide, they prevail. Several of the documents listed originate outside Europe and may be applied as reference rather than as adopted requirements — establish their status locally before citing them in a contract.

About APIS

APIS is an integrated engineering group founded in Kosovo, operating across the Western Balkans and into the European Union. The Group delivers mechanical, electrical, energy and infrastructure works through twenty-one delivery divisions across two strategic business units — Building Systems & Technologies, and Energy, Industry & Infrastructure — supported by four engineering excellence centres. APIS operates management systems certified to ISO 9001, ISO 14001, ISO 45001 and ISO 50001.

The **Energy Division** delivers generation, storage and efficiency projects from feasibility and load analysis through design, grid connection, installation, commissioning and ongoing performance verification. Work is delivered under the Group's DBOM lifecycle model — design, build, operate and maintain — so that the party which sizes the system is accountable for what it delivers.

Prepared by the APIS Battery Energy Storage (BESS) Division · **Document** APS-GD-03 issue v1.0 of 18 August 2026 · **Contact** apisgroup.net/contact

Been shown a storage proposal, and not sure *what to ask?*

Every serious storage project starts with twelve months of your own interval data and one clear sentence about what the battery is for. Our engineers will analyse the data, produce the sizing curve, and tell you what the system should actually be — or whether it should be built at all.

SPEAK TO THE BATTERY STORAGE DIVISION

Load profile analysis · use case definition and sizing · fire and siting strategy · grid connection · tender review · commissioning and performance verification

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APS-GD-03 v1.0 · 18.08.2026

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