APIS GUIDE 13 · BUILDINGS

Electrical capacity *and resilience.*

Your incoming supply is the constraint on everything you want to do next — solar, charging, storage, expansion, heat pumps. And you almost certainly do not know what it is.

APIS · ELECTRICAL & LIGHTING

26 pages · PDF · English
Issue v1.0 · 20 August 2026
apisgroup.net/guides-ebooks

ABOUT THIS GUIDE

The constraint behind *every other project.*

Almost every improvement a building owner now wants to make is electrical. Solar generation. Vehicle charging. Battery storage. Heat pumps replacing gas. Denser occupancy. More computing. Each is a separate project with its own case — and each arrives at the same question, usually late: **will the supply take it?**

That question is answered badly more often than not, in one of two directions. Either an upgrade is assumed necessary and priced into a project that did not need one, killing the case. Or capacity is assumed available and the constraint is discovered after commitment, when the connection process takes longer than the programme allows.

Both failures come from the same root: the building's actual electrical position has never been established. The nameplate ratings are known, the contracted capacity is on an invoice somewhere, and the number that matters **— what the building actually draws at its worst hour —** has never been read, although it is usually already being recorded.

> WHAT THIS GUIDE WILL NOT TELL YOU
>
> **No diversity factors, no demand figures, no cable sizes, no protection settings, no voltage limits, no harmonic limits, no standby durations.** Every one of those is a design output for a specific installation, produced by a qualified electrical designer against the standards and the distribution operator's requirements in force where the building stands.
>
> What this guide gives is the structure: what to measure, what to ask, what the answers mean, and how to sequence an upgrade so it does not become the thing that delays everything else. It is written for the person deciding, not the person designing.

Who this is written for

- Building owners and asset managers planning any of the projects above
- Facilities and technical managers who will be asked whether the supply can take it
- Industrial and commercial operators adding process load or expanding
- Developers and their advisers assessing a site's electrical position before committing
- Boards and investment committees reading a proposal that depends on an assumption about capacity

What this guide is not

It is not a design document and does not replace a qualified electrical designer. It does not cover lighting design, which is a substantial subject of its own, nor the detailed design of any installation. It concerns **capacity, distribution and resilience** — what the building can supply, to what, and how reliably.

How it relates to the other guides in this series

This is the constraint several other guides refer to and none of them covers. Guide 06 asks whether the connection can accept export. Guide 08 asks whether it can take chargers. Guide 03 asks what a battery is connecting to. Guide 09 asks what capacity a new tenant will need. Guide 11 asks the same question across a whole portfolio. **This guide is the one that answers them.**

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Document APS-GD-13, issue v1.0 of 20 August 2026. Prepared by the APIS Electrical & Lighting Division.

SECTION 01

The question everything *else waits on.*

And the two ways it is answered wrongly, both of which cost more than answering it properly would have.

The electrical capacity question arrives at the end of most projects and belongs at the start. By the time it is asked, a scheme has been designed, a budget has been set and a programme has been committed — and the answer, whichever way it goes, disrupts all three.

THE TWO FAILURES

Failure	What happens	What it costs
Assuming an upgrade is needed	A supply upgrade is priced into the project because nobody established what headroom already exists. The case weakens or fails	**The project does not happen**, or happens smaller than it needed to. This is the more common failure and the more invisible one, because nobody ever finds out the upgrade was unnecessary
Assuming capacity is available	The scheme proceeds, the constraint appears at detailed design or at connection application, and reinforcement is required	Cost, and worse, **time**. Connection processes run to their own timetable and cannot be accelerated by paying more. Programmes slip by quarters

THE SINGLE MOST USEFUL THING IN THIS GUIDE

Get twelve months of interval consumption data for your incoming supply, and find the highest half-hour in it.

That number is your measured peak. Compared against your contracted or available capacity, it tells you how much headroom you have — and for most buildings the answer is materially more than anyone assumed, because the assumption was based on connected load rather than on what the building actually draws. Section 02 explains why those differ so much.

The data usually already exists. It is held by your supplier or by the distribution system operator, and it is generally available for the asking. **It costs an email and it is the foundation of every decision in this guide.**

What is driving the question now

Electrical demand in buildings is rising for reasons that are structural rather than cyclical, and they compound:

- **Electrification of heat** — heat pumps replacing gas or oil, moving a large seasonal load onto the electrical supply. Guide 02 covers the district heating alternative
- **Vehicle charging** — potentially the largest single new load a site will ever add. Guides 08 and 11
- **On-site generation and storage**, which change the connection question in both directions — import and export. Guides 03 and 06
- **Computing and data loads**, which have grown in density faster than the buildings housing them
- **Denser occupancy and changed use**, particularly in buildings converted from what they were designed for
- **Cooling**, as summer peaks lengthen and cooling load rises in buildings that were designed around heating

Each of these is normally assessed alone. **Assessed together — which is the only honest way, since they land on the same supply — the picture is frequently different**, and the sequencing between them starts to matter.

> ASK THE QUESTION ONCE, FOR EVERYTHING
>
> If you are considering solar, charging, storage or heat pumps within the same five years, do not ask the capacity question separately for each. Establish the position once, model the combined effect, and decide the sequence.
>
> The reason is practical: **an upgrade triggered by one project creates headroom the others can use**, and the order in which they are built changes what each costs. Assessed separately, each carries a share of an upgrade the first one alone would have paid for. Section 08.

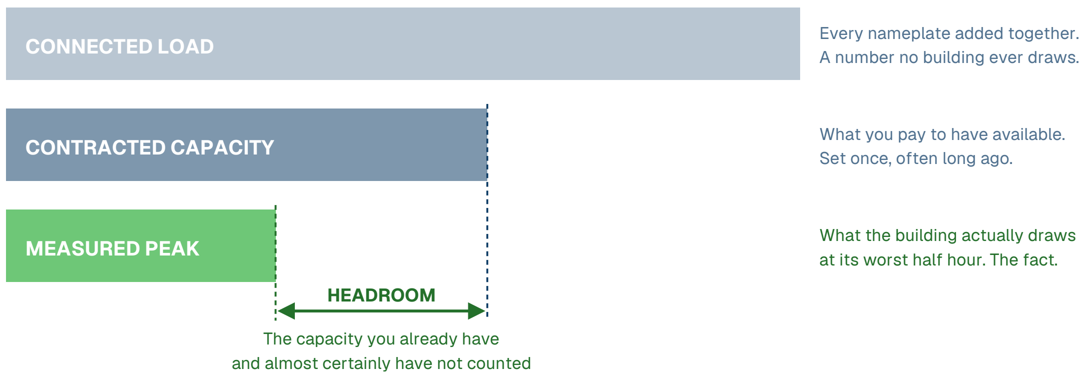
SECTION 02

Connected load *is not demand.*

The confusion behind most unnecessary upgrades, and behind most unpleasant surprises.

Three different numbers describe a building's electrical position. They are routinely used interchangeably, they can differ by a large margin, and almost every capacity mistake comes from substituting one for another.

THREE NUMBERS THAT ARE ROUTINELY CONFUSED



Sizing an upgrade from connected load prices capacity the building has never used. Sizing it from the meter prices what it needs.

Bar lengths are illustrative of the relationship, not measurements. The gaps differ in every building.

Figure 2.1 — The three numbers and the headroom between them. Bar lengths illustrate the relationship only and are not derived from any dataset; the gaps differ in every building.

The three numbers

Number	What it is	Why it misleads
Connected load	The arithmetic sum of every nameplate rating in the building	It assumes everything runs simultaneously at full rating, which never happens. Lifts are not all rising at once, motors do not run at nameplate, cooling and heating do not peak together, and half the equipment is off. **Sizing anything from this number buys capacity that will never be used**
Contracted or available capacity	What your agreement with the operator entitles you to draw, and what the connection is rated for	It was set once, often decades ago, on assumptions nobody recorded — and the building has changed since, in both directions. It is a commercial figure as much as a technical one, and it may be higher or lower than what the physical connection could actually carry
Measured peak demand	The highest actual draw recorded, over a defined interval, across a full year	It does not mislead. It is the fact. **Its weakness is only that most buildings have never looked at it**

> DIVERSITY IS THE REASON FOR THE GAP, AND IT IS NOT A RULE OF THUMB
>
> The difference between connected load and actual demand is diversity — the fact that loads do not all draw maximum power at the same moment. Standards and design practice provide methods for estimating it, and a designer will apply them where no measurement exists.
>
> But **an estimated diversity factor is an assumption and a measured peak is evidence**, and where the building already exists there is no reason to prefer the assumption. This guide states no diversity factor deliberately — the point is not what value to use, it is that you should not need one.
>
> For a new building, or a new load in an existing one, estimation is unavoidable. **Where it is, ask what factors were used and on what basis** — and expect the answer to be conservative, because the designer carries the risk of it being too low and none of the cost of it being too high.

What the measured peak does and does not tell you

- **It tells you the historic worst case** under the building's current use, with its current equipment and its current occupancy. That is a fact and a good basis
- **It does not include anything you are about to add.** The new load must be added to it, with its own coincidence considered — a charger peak that lands at the same hour as the building peak is a very different proposition from one that lands at night
- **It reflects the weather that occurred**, not the design condition. A mild year understates a cooling-driven peak, and one hot week can set the annual figure
- **It may already be constrained** — if something has been tripping, or if a control system is limiting demand, the peak you measure is what the building was allowed to draw rather than what it wanted
- **It hides the shape.** The peak is one number; the profile behind it tells you when there is spare capacity, which is what makes managed charging and load shifting possible. Guides 08 and 11 depend on this

> LOOK AT THE WHOLE YEAR, AND LOOK AT THE SHAPE
>
> Request the interval data rather than a summary. A single "maximum demand" figure from an invoice is one number; a year of half-hourly data is a picture of how the building behaves, and it answers questions the single number cannot: when the peak occurs, how long it lasts, how often it is approached, whether it is driven by heating or cooling, and how much of the day sits far below it.
>
> That picture is what turns "we have no capacity" into "we have no capacity between eleven and three on a hot Tuesday" — which is a completely different and much more solvable problem.

SECTION 03

Reading *your own installation.*

Six documents and one survey. Most buildings have none of them, and assembling them is the cheapest engineering work available.

Before any designer can answer a capacity question, somebody has to establish what is actually installed. In most existing buildings that information has been lost incrementally — through alterations recorded nowhere, contractors who left with the drawings, and changes made by whoever was available at the time.

WHAT TO ASSEMBLE

Item	What it tells you, and what its absence tells you
The single-line diagram	How power flows from the incoming supply through every board to every final circuit. **The single most valuable document about a building's electrical installation**, and the one most often missing or years out of date. Without it, every subsequent question is answered by opening panels
The supply agreement	Contracted capacity, tariff structure, whether capacity charges apply and on what basis. Frequently held by finance and never seen by anyone technical
Interval consumption data	Section 02. The whole year, half-hourly, not a summary
The most recent inspection and test report	Condition of the installation, and any observations that remain open. **Open observations are a liability and a constraint** — some will need clearing before any addition is made
Board schedules	What each way feeds, its rating, and which ways are spare. Frequently wrong, because circuits get reused without the schedule being updated
Records of alterations	What has been added since construction. The absence of these records is itself the finding — it means the installation differs from any drawing in ways nobody has catalogued
A physical survey	The one thing that cannot be assembled from files. Somebody competent opening the boards and comparing what is there with what the documents say

IF THE SINGLE-LINE DIAGRAM DOES NOT EXIST, PRODUCE ONE FIRST

It is a defined piece of work, it costs a fraction of any project that depends on it, and it is reusable for every subsequent project for the life of the building. Every capacity question, every resilience decision, every new load and every fault investigation starts by asking what it shows.

A building that commissions solar, then charging, then storage, then an expansion — each with a designer re-establishing the same information from scratch — pays for that survey four times. **Produce it once, keep it current as a condition of any works, and it becomes an asset rather than a repeated cost.**

What the survey should establish

- **The incoming arrangement —** where the supply enters, the metering position, the main switch, and whether the transformer is the operator's or yours. That last point changes who is responsible for what and is frequently unclear
- **Main switchboard age, condition and type**, and whether replacement components are still available. **An obsolete main board is a major constraint —** it may be impossible to extend, and replacing it usually requires a shutdown of the whole building
- **Spare ways at every board**, and separately, whether the board has thermal headroom to use them. Section 05 — these are not the same thing
- **Cable routes, containment and spare capacity** in risers and ducts. Adding a circuit is easy where there is a route and expensive where there is not
- **Earthing and bonding arrangement**, and its suitability for what is proposed. Several of the projects in Section 01 raise specific earthing questions
- **Protection coordination —** whether discrimination has ever been studied, and whether it still holds after the alterations
- **Standby and UPS provision**, its capacity, age, battery condition, and what it actually feeds today rather than what it was installed to feed. Section 06
- **Power factor correction**, if present — whether it is working, and whether its capacitors have been maintained. Failed correction equipment is common and is usually discovered from the invoice rather than from an alarm
- **Signs of uncontrolled growth —** extension leads in permanent use, boards with handwritten labels, unlabelled ways, temporary supplies that became permanent. Each is both a safety observation and evidence about how the installation has been managed

> THE OBSERVATIONS THAT MUST BE CLEARED BEFORE ANYTHING IS ADDED
>
> An installation with open observations from its last inspection is not a stable base to build on. Some are advisory; some indicate a condition that must be corrected before any addition can be certified.
>
> **Establish the status of every open observation before designing an addition**, and price the clearing of them within the project rather than discovering them at the point of certification. This is the electrical equivalent of the compliance register in Guide 04, and it is the most common reason an otherwise simple addition becomes a larger job.

SECTION 04

The connection, and the conversation *with the operator.*

The longest lead item in any electrical project, processed on its own timetable, and the one that cannot be accelerated by paying more.

Where the measured peak plus the new load exceeds what the connection can carry, the distribution system operator becomes the determining party in your project. Everything after that point runs at their pace, and the single most valuable thing you can do is start early and ask well.

SIX QUESTIONS FOR THE OPERATOR, ASKED AT FEASIBILITY RATHER THAN AT DESIGN

1. **What capacity is available at this connection today, without any reinforcement?** Confirmed in writing. This is frequently more than the contracted figure and occasionally less than the physical connection suggests
2. **What would reinforcement cost, and how long would it take?** The programme answer usually matters more than the cost answer
3. **Is there work already planned on this part of the network** that would change the position, and when? Operators hold this and are rarely asked
4. **Can available capacity be secured or reserved**, on what terms, and for how long? Headroom identified today is not held for you
5. **Do you offer a flexible or curtailable connection**, and what would it mean operationally? For manageable loads this can unlock a project that a firm connection would not
6. **What are the requirements for export**, if generation or storage is contemplated now or later? Ask even if it is not in this project — the answer affects how you design this one

Ask all six at once, in one letter, before design begins. The answers frequently change the project, and receiving them after the design is complete is how programmes slip.

What determines the answer

- **Capacity on the network, not just at your connection.** Your connection may be rated for more than the local network can supply, and the constraint may be several steps upstream from your building
- **Your voltage level.** A low-voltage connection has a ceiling; beyond it the answer is a medium-voltage connection with your own transformer, which is a different project with different space, safety and maintenance obligations
- **What else has been connected recently or is queued.** Capacity is allocated as applications arrive, and a neighbouring development can consume the headroom you were counting on
- **The nature of your load.** A load that is manageable, shiftable or curtailable is a different proposition to the operator than one that is not — which is why Section 06 of Guide 08 and Section 04 of Guide 11 matter here

Where the answer is “reinforcement required”

That is not the end of the assessment. Four routes remain, and they should be examined before the reinforcement is accepted as the answer:

1. **Reduce the existing peak.** If the building’s own peak can be lowered, the headroom for the new load appears without touching the connection. Guide 05 sets out how to find where a peak comes from — and the measures are frequently ones you wanted anyway
2. **Manage the new load.** A load that can be limited, scheduled or shed does not need firm capacity. This is the whole argument of Guide 08 §04, and it applies to far more than charging
3. **Shift it in time.** The profile from Section 02 usually shows large periods well below peak. A load that can run then may need no additional capacity at all
4. **Storage.** On-site storage can serve a short high peak from a smaller connection, converting a network problem into an equipment decision. It is a separate investment with its own case — Guide 03 — and should be assessed on its own terms rather than assumed into the answer

Only when these have been examined is a reinforcement genuinely necessary — and by then you know what size of reinforcement, which is usually smaller than the first estimate.

> APPLY EARLY, AND APPLY FOR THE END STATE
>
> Connection applications take what they take. Submitting one early costs little and preserves optionality; submitting one late puts the operator’s timetable in series with your own.
>
> And **consider applying for the capacity you will need in five years rather than the capacity this project needs** — weighing that against any standing charge on unused capacity. Going back a second time means a second application, a second wait, and possibly a second reinforcement that the first one could have covered.

SECTION 05

Distribution — where the capacity *actually runs out.*

The supply is frequently not the constraint. The board you need to connect to usually is.

A building can have ample capacity at the incoming supply and no practical way to use it, because the distribution between the supply and the point of use will not carry it. This is the constraint discovered second — after the connection question is answered favourably — and it is often the more expensive of the two.

SPARE WAYS ARE NOT SPARE CAPACITY

A distribution board with free ways looks like a board with room. It may not be. Two separate questions must both be answered yes:

Are there physical spare ways? Somewhere to fit the device.
Does the board have capacity to supply them? The incoming device, the busbar and the supplying cable must carry the additional load, and the board's thermal rating must accommodate it.

A board can have ten spare ways and no capacity, or no spare ways and ample capacity — the second is solvable, the first is not. **Ask both questions of every board in the path**, and expect the answer to come from a designer with the schedule and the measurements, not from looking at the board.

The path, and what constrains it at each step

Element	What constrains it
Main switchboard	Rating, condition, available outgoing ways, and — critically — **whether the type is still supported**. An obsolete board cannot be extended and its replacement usually requires a whole-building shutdown, which makes it a programme problem as much as a cost one
Sub-main cables	Rating, route, and installed condition. Replacing a sub-main through an occupied building is disruptive and frequently the largest single item in an upgrade
Distribution boards	Both questions above. Also age and spares availability — the same obsolescence issue in miniature, repeated across the building
Containment and routes	Whether there is physical room for another cable. Full containment turns a simple addition into a builder's job
Protection coordination	Whether discrimination still holds once devices are added. A new device that trips the board above it instead of itself turns a local fault into a building outage
Fault level	Whether existing equipment remains adequately rated. **A network reinforcement can raise the fault level at your installation** — the upgrade that gave you capacity can render your switchgear inadequate, and this is a check that gets missed
Earthing and bonding	Whether the arrangement suits the addition. Charging, generation and storage each raise specific questions here
Metering	Whether the new load can be measured separately, which matters for cost allocation, for tenant recharging and for demonstrating anything afterwards. Guide 09 §03

THE FAULT LEVEL CHECK THAT GETS MISSED

Reinforcing a supply, or moving to a larger transformer, generally increases the prospective fault current at the installation. Existing switchgear is rated for a fault level, and equipment that was adequate before the upgrade may not be after it.

This is a calculation, not an inspection, and it belongs in the design of any capacity increase. **Ask explicitly whether the fault level has been reassessed** — the consequence of missing it is that protective equipment may not safely interrupt a fault, and the failure only appears when it is needed.

Designing distribution so it does not constrain the next project

The same argument as the ducting in Guides 08 and 11, applied to switchgear: the expensive part is the access and the disruption, not the component.

- **Spare ways and spare capacity** at every new board, deliberately, with the quantity a stated decision rather than whatever the standard board size gave
- **Physical space in switchrooms** for the board that will be needed later, kept clear and recorded as reserved rather than gradually filled with storage
- **Containment sized for the end state** — the cost of larger containment is marginal, and the cost of adding a second route through a finished building is not
- **Sub-mains sized for the growth position**, since cable is a modest share of the cost of installing cable
- **Metering designed in** at the boundaries that will matter
- **The single-line diagram updated** as a required deliverable of the works. Section 03 — this is how it stays useful instead of decaying

SECTION 06

Resilience is *a duration question.*

Not whether you have standby power, but what must stay on, for how long, and how quickly — three answers that produce entirely different systems.

Resilience is usually procured as a product: a generator, or a UPS. It should be specified as a requirement, and the requirement has three dimensions that must each be answered before anything is selected.

THE THREE QUESTIONS

Question	What it establishes	What it changes
What must stay on?	Which loads, specifically, by circuit. Not "the critical areas" — a list	The size of everything. **This list is almost always shorter than the first answer**, and shortening it is the cheapest resilience measure available
For how long?	Minutes, hours, or days. Long enough to shut down safely, to evacuate, to ride through a typical outage, or to keep operating indefinitely	The technology. Minutes is a battery question; days is a fuel and refuelling question with its own logistics and storage obligations
How quickly?	Whether a break in supply is acceptable, and how long a break	Whether a generator alone suffices or whether uninterruptible supply is required. **A generator takes time to start and accept load** — for some equipment that gap is irrelevant and for some it is the whole problem

WRITE THE LIST OF ESSENTIAL LOADS, BY CIRCUIT, AND THEN ARGUE ABOUT IT

Asked in the abstract, most organisations classify far more as essential than they can justify. Asked circuit by circuit, with the cost of each on the table, the list gets shorter and better.

Two categories are frequently confused and should be separated: **loads required for life safety and statutory compliance** — emergency lighting, fire systems, and whatever else the fire strategy depends on, which are not negotiable; and **loads required for business continuity**, which are a commercial decision and should be justified by what an outage actually costs.

Guide 12 in this series covers the first category from the fire side, and the two lists must be reconciled — **an essential-load schedule that omits something the fire strategy relies on is a serious finding**, and it is found by comparing the two documents, which is rarely done.

What resilience provision brings with it

- **A dedicated essential distribution** — separate boards and circuits, which is straightforward in a new building and intrusive in an existing one
- **Changeover arrangements**, and their own failure modes. A changeover that does not operate is the commonest way a standby system fails to deliver
- **Fuel storage, containment and its regulatory obligations**, plus fuel condition over time — fuel degrades, and a generator that has never run on old fuel may not run on it
- **Batteries with a defined life**, a replacement date, and a disposal obligation. Guide 03 covers the storage question at larger scale

- **Space, ventilation, noise, emissions and access**, all of which are frequently discovered after the equipment is selected
- **A testing regime** — below

> TESTED MONTHLY AND NEVER TESTED UNDER LOAD
>
> The commonest defect in standby provision is a system that is exercised regularly off load and has never been proved on load. It starts, it runs, it is signed off — and it has never been asked to do the thing it exists to do.
>
> **Specify and contract for periodic testing on load**, for the full specified duration, with the essential distribution actually transferred and the building running on it. Anything less proves the engine starts, which was not the question.
>
> Test also what happens on **return** to mains supply, which is a separate event with its own failure modes, and confirm what the building does if the standby system itself fails.

The cheaper resilience measures, considered first

Standby generation is the expensive answer and sometimes the necessary one. Before it:

1. **Shorten the essential load list.** The single largest lever
2. **Establish what outages actually occur** — frequency and duration, from the operator and from your own records. Resilience designed against an assumption about supply reliability, when the actual record is available, is guesswork with hardware attached
3. **Ask whether the consequence can be engineered out** — a process that can pause safely, a data system that fails over elsewhere, a cold store with enough thermal mass to ride through. These are frequently cheaper than the electrical solution
4. **Consider a second supply** where the operator can offer one and the risk justifies it — noting that two supplies from the same upstream point protect against less than they appear to

SECTION 07

Power quality, and the loads *that misbehave.*

The problem created by exactly the equipment installed to improve efficiency — and the one that gets diagnosed last because nothing appears broken.

Older electrical installations supplied loads that drew current smoothly. Modern ones supply electronics: variable speed drives, LED drivers, inverters, chargers, uninterruptible supplies, computing equipment. These draw current in pulses rather than smoothly, and the effects accumulate across an installation as more of them are added.

The result is a class of problem that presents as unexplained heat, nuisance tripping, equipment that fails earlier than it should, and a supply that appears adequate on paper and misbehaves in practice.

THE IRONY WORTH NAMING

Almost every energy efficiency measure a building installs is a non-linear load. Variable speed drives on pumps and fans. LED lighting. Heat pump inverters. Solar inverters. Vehicle chargers. Battery converters.

Each is individually beneficial and correct. **Collectively, and without assessment, they can degrade the power quality of the installation supplying them —** and the building that has done the most to improve its efficiency may be the one most exposed to this.

The point is not to avoid them. It is that **a building progressively converting to electronic loads should have its power quality assessed at some point in that journey**, and almost none do.

What to be aware of, and what it looks like

Phenomenon	What it is	How it presents
Harmonic currents	Current drawn at multiples of the supply frequency by non-linear loads	Additional heating in cables, transformers and switchgear. Equipment running hotter than its loading suggests. Reduced effective capacity in the distribution
Neutral currents	In three-phase systems, certain harmonics add in the neutral rather than cancelling	**A neutral conductor carrying more current than the phases**, which older installations were not designed for. A recognised and frequently overlooked risk in buildings with many single-phase electronic loads
Phase imbalance	Load distributed unevenly across the three phases	One phase near its limit while the installation appears lightly loaded overall. **Frequently the reason a building has “no capacity”** when it in fact has capacity on two phases
Poor power factor	Current drawn that does no useful work	Capacity consumed for nothing, and in many tariffs a charge. Correction equipment exists in many buildings and has frequently failed unnoticed
Voltage disturbances	Dips, swells, flicker and transients, from within the installation or from the network	Sensitive equipment resetting or failing. EN 50160 describes the voltage characteristics of public distribution networks and is the reference point for what the supply should deliver
Nuisance tripping	Protective devices operating with no fault present	Frequently harmonic or leakage-current related, and frequently “solved” by fitting a larger device — which removes the symptom and the protection together

WHEN TO MEASURE RATHER THAN ASSUME

Power quality is measured with instruments over a period, not inferred. It is worth measuring when any of these apply:

- A significant proportion of the load has become electronic, or is about to
- Nuisance tripping is occurring and no fault is found
- Equipment or cables are running hot without obvious overload
- Sensitive equipment is resetting or failing unexpectedly
- A substantial new non-linear load is proposed — chargers, drives, inverters
- Capacity appears exhausted and the measured peak does not support that conclusion

The last one is the most useful. **Where the numbers say there is capacity and the building behaves as though there is not, power quality or phase imbalance is frequently the explanation** — and both are cheaper to fix than a reinforcement.

Specify against it, rather than diagnosing it later

- **Require harmonic performance data** for significant non-linear equipment being procured, and require the designer to assess the cumulative effect rather than each item alone
- **Require the neutral to be assessed** where single-phase electronic load is significant

- **Require balanced distribution across phases**, and require it to be verified at commissioning rather than intended at design
- **Specify appropriate protective device types** for the loads being supplied. Guide 08 §06 raises this specifically for charging, and the same class of question arises for drives and inverters
- **Include a power quality measurement** in the survey where any of the triggers above apply, before the design rather than after the complaint

SECTION 08

Specifying and phasing *an upgrade.*

Sequencing decides the cost. The same set of works, ordered differently, can differ by a large margin — and the ordering is a decision, not a consequence.

An electrical upgrade in an occupied building is disruptive, is constrained by shutdown opportunities, and has a long-lead item at the front of it. These three facts should shape the plan and usually do not.

> THE SEQUENCING RULE
>
> **Start the connection application first, do the disruptive works during the wait, and keep the shutdown-dependent work together in one outage.**
>
> Connection processes run on the operator’s timetable. That waiting period is otherwise dead time, and it is exactly long enough to complete surveys, produce the single-line diagram, clear open observations, install containment and pull cables — none of which depends on the new capacity existing.
>
> Sequenced the other way — design, procure, install, then apply — the operator’s timetable is added to the end of the project rather than absorbed into it.

What the specification must contain

Item	Why
The load assessment and its basis	Measured peak, the new load, coincidence assumptions, and the growth position. So every bidder prices the same requirement
The single-line diagram, existing and proposed	Section 03. The document that makes the scope unambiguous
Boards, ways and spare capacity required	Stated by you, not proposed. Section 05 — spare provision is a decision that will otherwise be value-engineered out
Fault level assessment required	Explicitly. Section 05 — this is the check that gets missed
Protection coordination study required	With the results issued, not just applied
Power quality requirements	Section 07, where the load justifies it
Earthing arrangement	Confirmed suitable for what is being added, or a designed alternative
Metering	What is metered separately and to what standard. Billing-grade where energy will be recharged — that approval cannot be retrofitted
Shutdown windows and constraints	Stated in the tender. A bidder who does not know the outage constraints has not priced the job you have
Clearing of open observations	In scope, priced, not discovered
Documentation deliverables	Updated single-line diagram, board schedules, test certificates, protection settings as applied. Below

THE SHUTDOWN IS THE PROGRAMME, NOT THE WORKS

In an occupied building the constraint is rarely how long the work takes. It is how many outages are available, how long each can be, and when.

Establish the shutdown opportunities before designing the phasing — a building with one available weekend a quarter needs a different plan from one that can close for a week. And **consolidate everything shutdown-dependent into as few outages as possible**, including work for projects not yet approved. Opening the main switchboard is the expensive part; what you do while it is open is comparatively cheap.

This is the electrical version of the trench-once argument in Guides 08 and 11, and it has the same force.

Handover — the documents that keep the next project cheap

- **The updated single-line diagram**, as installed. The most important deliverable and the one most often promised and not delivered
- **Board schedules**, accurate, with spare ways identified and the spare capacity at each board stated
- **Inspection and test certification** for the new work, with any observations listed and closed
- **Protection settings as applied**, and the coordination study behind them

- **Fault level assessment** and its result
- **Confirmation of the connection agreement** as it now stands, including the contracted capacity, so the invoice and the installation agree
- **Metering schedule —** what is metered, where, and how it is read

Tie a retention to the delivery of this pack. Every one of these documents is easy to obtain before final payment and difficult afterwards, and each of them is what makes the next project on this building cost less than this one.

On costs generally. This guide states no figure. The cost of an electrical upgrade is dominated by three things a general document cannot know: whether the connection needs reinforcement, whether the main switchboard can be extended or must be replaced, and how many outages the building can offer. Establish those three and the estimate becomes reliable; before them, any figure is a placeholder.

SECTION 09

The forty-point *checklist.*

Work through it before committing to any project that adds electrical load. Every item is something to establish, require or verify.

A · ESTABLISH THE POSITION

- [ ] Twelve months of interval consumption data obtained for the incoming supply
- [ ] Measured peak identified, and the profile examined for shape as well as magnitude
- [ ] Contracted or available capacity established from the supply agreement
- [ ] Headroom calculated — measured peak against available capacity
- [ ] Connected load distinguished from demand, and no sizing based on nameplate sums
- [ ] Whether the existing peak is already constrained by tripping or demand limiting, established
- [ ] All electrical projects planned within five years listed and assessed together, not separately
- [ ] Single-line diagram obtained, or commissioned if it does not exist
- [ ] Most recent inspection and test report obtained, with open observations listed
- [ ] Physical survey carried out by a competent person, against the documents

B · THE CONNECTION

- [ ] Available capacity without reinforcement confirmed by the operator in writing
- [ ] Reinforcement cost and, more importantly, programme obtained
- [ ] Operator’s own planned network work established
- [ ] Whether available capacity can be reserved, and on what terms, established
- [ ] Flexible or curtailable connection options established
- [ ] Export requirements established, even if generation is not in this project
- [ ] Peak reduction examined before reinforcement is accepted as the answer
- [ ] Load management, time shifting and storage each examined as alternatives
- [ ] Connection application submitted early, ahead of detailed design
- [ ] Application made for the growth position, weighed against any standing charge

C · DISTRIBUTION AND RESILIENCE

- [ ] Every board in the path checked for spare ways and spare capacity, separately
- [ ] Main switchboard age, type and support status established
- [ ] Sub-main ratings and routes assessed
- [ ] Containment spare capacity assessed
- [ ] **Fault level reassessed where capacity is being increased**
- [ ] Protection coordination studied and discrimination confirmed to still hold
- [ ] Earthing and bonding arrangement confirmed suitable for what is being added
- [ ] Phase balance measured and corrected where it is masking available capacity
- [ ] Essential load list written by circuit, and challenged
- [ ] Essential load list reconciled against what the fire strategy relies on
- [ ] Resilience specified as duration and transfer time, not as a product
- [ ] Standby provision tested on load for the full duration, and on return to mains

D · POWER QUALITY, PROCUREMENT AND HANDOVER

- [ ] Power quality measured where any of the triggers apply, before design
- [ ] Harmonic performance data required for significant non-linear equipment, assessed cumulatively
- [ ] Neutral loading assessed where single-phase electronic load is significant
- [ ] Shutdown windows established before phasing is designed
- [ ] Shutdown-dependent work consolidated into as few outages as possible, including future scope
- [ ] Spare ways, spare capacity and containment specified for the end state, stated in the tender
- [ ] Clearing of open observations included in scope and priced
- [ ] Handover pack tied to a retention — updated single-line diagram, schedules, certification, protection settings, fault level assessment

Electrical position sign-off

Complete and retain with the project file.

ELECTRICAL CAPACITY SIGN-OFF

Item	Name and role	Date and signature
Building and proposed additional load		
Measured peak, period and source		
Available capacity confirmed by operator		
Single-line diagram current as at		
Fault level assessed by		
Essential load list agreed by		
Checklist points 1–40 confirmed		
Released for tender by		

IF YOU CAN ONLY DO THREE THINGS

One. Get the interval data and find your measured peak. It usually already exists, it costs an email, and it frequently shows headroom nobody had counted.

Two. Produce the single-line diagram if you do not have one. Every future electrical project on this building starts by asking what it shows, and without it each one pays to rediscover the same information.

Three. Ask the capacity question once for everything you plan within five years, and apply to the operator before you design. The sequence decides the cost more than the scope does.

REFERENCE

Standards referred to *in this guide.*

Listed by number and subject. Confirm the current edition and the national adoption before citing any of them in a contract document.

STANDARDS REGISTER

Reference	Subject
IEC 60364 / HD 60364 series	Low-voltage electrical installations — the principal series, covering design, protection, selection and erection, and inspection and testing
IEC 60364-8-1	Low-voltage electrical installations — energy efficiency, addressing the assessment and design of installations for efficient use
IEC 61439 series	Low-voltage switchgear and controlgear assemblies — the standard behind board ratings and verification
IEC 60947 series	Low-voltage switchgear and controlgear — the devices themselves
IEC 60909 series	Short-circuit currents in three-phase AC systems — the calculation behind the fault level assessment in Section 05
EN 50160	Voltage characteristics of electricity supplied by public distribution networks — the reference point for what the supply should deliver. Section 07
IEC 61000 series	Electromagnetic compatibility — including the parts addressing harmonic current emission and immunity
IEC 62305 series	Protection against lightning
EN 50549 series	Requirements for generating plants connected in parallel with distribution networks — where generation or storage is contemplated. Guides 03 and 06
IEC 60364-7-712	Low-voltage installations — supplies for electric vehicles. Guides 08 and 11
EN 50600 series	Information technology — data centre facilities and infrastructures, including power distribution and availability classification. Relevant where resilience requirements are driven by IT
EN 12464-1	Light and lighting — lighting of work places, indoor. Listed for completeness; **lighting design is a substantial subject not covered by this guide**
ISO 50001	Energy management systems — relevant where the installation supports a formal energy programme. Guide 05

HOW TO USE THIS REGISTER — AND WHAT GOVERNS ABOVE IT

Standards are revised, withdrawn and superseded. Verify the current edition and the national adoption with the 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.

Three things govern above all of the above: the national electrical legislation and wiring regulations in force where the building stands; the connection conditions and technical requirements of the distribution system operator, which prevail over general standards for anything at the connection boundary; and the design of a qualified electrical designer for the specific installation. Where this guide is silent on a numeric value, that silence is deliberate and those are the sources that supply it.

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 **Electrical & Lighting Division** carries out capacity assessment, single-line diagram production and installation survey, connection applications and operator liaison, distribution and switchgear design, resilience and standby provision, power quality measurement, and the installation and commissioning that follows. Because APIS also delivers the projects that create the demand — solar, charging, storage, heat pumps — the capacity question is usually asked here before it becomes a constraint elsewhere.

Prepared by the APIS Electrical & Lighting Division · **Document** APS-GD-13 issue v1.0 of 20 August 2026 · **Contact** apisgroup.net/contact

Been told you need a supply upgrade, *but nobody read your meter?*

It happens constantly. Our engineers will read twelve months of your interval data, establish what your building actually draws at its worst hour, survey what is installed between your supply and your loads, and tell you what you can add without touching the connection at all — which is frequently more than anyone assumed.

SPEAK TO THE ELECTRICAL & LIGHTING DIVISION

Capacity assessment from measured data · installation survey and single-line diagrams · connection applications and operator liaison · distribution and switchgear design · fault level and protection coordination · resilience and standby provision · power quality measurement · installation and commissioning

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APS-GD-13 v1.0 · 20.08.2026

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