APIS GUIDE 06 · ENERGY

Solar PV for *commercial buildings.*

Sizing to the load, reading a yield estimate, and the roof questions that decide whether the array can be built at all — for owners, operators and the people approving the investment.

APIS · SOLAR ENERGY DIVISION

28 pages · PDF · English

Issue v1.0 · 20 August 2026

apisgroup.net/guides-ebooks

ABOUT THIS GUIDE

The roof is not *the constraint.*

Almost every commercial solar proposal starts from the roof: here is the available area, here is what fits on it, here is the annual yield. It is the wrong starting point, and it produces arrays that generate impressively and earn disappointingly.

The number that decides a commercial solar investment is not the roof area and not the annual yield. It is the **proportion of generation the building consumes itself** — because the value of a kilowatt-hour you use is the price you avoid paying, and the value of one you export is whatever the rules currently allow. Those two numbers are usually very different, and the gap between them is the whole business case.

This guide covers how to establish what the array is actually for, what the roof survey must settle before anyone quotes, how to size to the load rather than to the available area, how to interrogate a yield estimate, what the electrical design and the grid connection involve, the fire and insurance questions that arrive late and expensively, and what the warranties actually promise. It ends with a forty-point checklist you can attach to a tender.

> WHAT THIS GUIDE CANNOT TELL YOU, AND WHY
>
> The value of exported energy, whether export is permitted at all, what net metering or net billing arrangements apply, and what support schemes exist are set by regulation where the building is — and they change. **No figure in this guide is a tariff, a yield, a payback or a return.**
>
> What it 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 whatever commercial evaluation you build rests on something real. Section 08 sets those out.

Who this is written for

- Owners and operators of factories, warehouses, cold stores, logistics facilities, retail and office buildings
- Landlords considering an array on a tenanted building, where who consumes the energy is a lease question
- Public bodies and municipalities procuring rooftop solar on their own estate
- Boards, banks and investment committees evaluating a proposal somebody else prepared
- Consultants and contractors specifying or reviewing a rooftop system

What this guide is not

It covers **rooftop and building-mounted PV on commercial and industrial buildings**. It does not cover utility-scale ground-mounted plant, which is a different discipline with different economics, planning and grid arrangements; nor domestic installations; nor solar thermal, which is a different technology serving a different load. It is not a design document and does not replace a qualified electrical designer, a structural engineer or a fire engineer.

How to use it

If you are considering an array: Sections 01 to 03 are the feasibility stage and should be worked through before anyone is invited to quote. If you have quotations in front of you: Sections 04 to 07 are how to compare them, and Section 04 in particular is how to tell a credible yield estimate from an optimistic one. Section 09 is the checklist.

Contents

SECTIONS

APIS Ltd. (APIS sh.p.k.) · Rruga Prishtinë–Lipjan km 10, Livagjë, 10500 Graçanica, Republic of Kosovo · +383 49 787 233 · apisgroup.net

Document APS-GD-06, issue v1.0 of 20 August 2026. Prepared by the APIS Solar Energy Division.

SECTION 01

What is the array *for?*

Three answers, and they produce three different systems. The one that dominates commercial rooftop is self-consumption — and it is the one most proposals optimise for last.

A photovoltaic array converts sunlight into electricity at times determined by the sun, not by your building. Whether that is valuable depends entirely on what your building is doing at those times, and on what happens to whatever it does not use.

The three purposes

1 · Self-consumption — displacing energy you would otherwise buy

Every kilowatt-hour generated and consumed on site is a kilowatt-hour not purchased, avoided at the full delivered import price including all its components. This is almost always the most valuable use of generation, and for most commercial buildings it should be the primary design objective.

What it demands: an array sized to what the building actually consumes during daylight hours, which requires the load data in Section 03. The binding constraint is the load, not the roof.

2 · Export — selling what you do not use

Whatever the building does not consume goes to the network, and earns whatever the applicable arrangement allows. That value is set by regulation, it is usually well below the import price, and it can change during the array's twenty-five-year life.

What it demands: confirmation that export is permitted at all, at what limit, and on what commercial terms. Some connections are granted on a zero-export basis, which is technically straightforward but must be designed in and demonstrated.

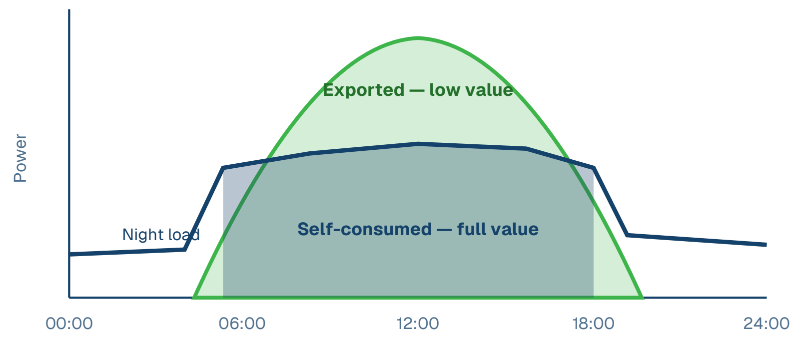
3 · Corporate, contractual or reporting objectives

Emissions targets, a customer's supply-chain requirement, a lender's condition, a certification scheme, or a visible commitment on a building people can see.

What it demands: clarity about what evidence is required, because it is often specific — generation metering, certificates of origin, or a particular reporting boundary — and it is far cheaper to design in than to retrofit.

> THE ONE NUMBER THAT DECIDES THE CASE
>
> **The self-consumption fraction: the proportion of what the array generates that the building consumes itself.**
>
> A building occupied Monday to Friday, daytime, with a steady process load, may consume most of what a well-sized array produces. A building that operates at night, or closes at weekends, or has a load that peaks in the evening, will export a large share — at a much lower value.
>
> Two identical roofs on two identical buildings can therefore produce very different investments. Any proposal that does not state the expected self-consumption fraction, and show how it was derived from your own interval data, has not done the analysis that matters.

GENERATION MEETS LOAD — WHERE THE VALUE IS AND IS NOT



What changes the shaded area

- ◆ Operating hours — a night-shift site exports most of what it generates
- ◆ Weekend operation — five-day sites export two days in seven
- ◆ Array size — beyond a point, every extra panel only adds export
- ◆ Orientation — east-west spreads generation across the day
- ◆ Storage — moves the surplus into the evening. See Guide 03

Figure 1.1 — Generation against load on a working day. Only the overlap earns the full import price; the rest is exported at whatever the applicable arrangement allows. Curves are illustrative of the relationship, not of any building.

Four ways to increase the shaded area

1. **Size to the load.** The single most effective action, and the subject of Section 03. Beyond a certain size every additional panel contributes only export.
2. **Reconsider orientation.** Due-south maximises annual yield; an east–west arrangement produces less in total but spreads it across the morning and afternoon, which on a building with a broad daytime load can raise self-consumption enough to be worth more. It also typically allows more capacity on the same roof, because inter-row shading spacing differs.
3. **Shift load into daylight** where the process allows — batch operations, charging, water heating, thermal storage in a cold store. Frequently free, and frequently unexamined.
4. **Add storage** to move surplus into the evening. This is a separate investment with its own case — see Guide 03 in this series — and it should be evaluated on its own merits rather than bundled in to make the solar case work.

IF THE BUILDING IS TENANTED, ESTABLISH WHO CONSUMES THE ENERGY

On a landlord-owned array serving tenant-metered space, the generation has to reach a meter somebody pays. The arrangement — whether the landlord sells to the tenant, whether the lease permits it, what happens at lease end, and how it is metered and billed — is a legal and commercial question that must be settled **before** the electrical design, because it determines where the array connects.

An array installed on the landlord's supply serving a building whose tenants buy their own electricity can end up generating into a meter nobody is billed against. This is a recoverable mistake and an expensive one.

The screening question

From twelve months of my own interval data: how much of a proposed array's generation would this building actually have consumed, hour by hour?

If nobody can answer that, the first project is not solar. It is obtaining the interval data, exactly as in Section 03.

SECTION 02

The roof — can it take it, *and for how long?*

An array has a twenty-five-year design life. If the roof under it has ten years left, you have not built a twenty-five-year asset.

The roof survey is the item most often compressed and the one most capable of stopping a project after money has been spent. Six questions must be answered before anyone quotes.

1 · Will the structure carry it?

A rooftop array adds permanent load, and — more importantly — changes how wind and snow act on the roof. The assessment is a structural engineering task, referred to the Eurocodes for actions on structures: EN 1991-1-3 for snow and EN 1991-1-4 for wind, within the framework of EN 1990.

Three points that decide the outcome:

- **Ballasted systems add substantially more weight** than mechanically fixed ones, because they resist wind uplift with mass rather than with fixings. On a lightweight industrial roof this is frequently the binding constraint.
- **Wind uplift concentrates at edges and corners.** Array layouts must respect perimeter zones, which reduces usable area — and a proposal that fills the roof to its edges has not accounted for it.
- **Snow can accumulate differently** with an array present, drifting against module rows. The load case is not simply the original roof load plus the array weight.

Where original structural drawings do not exist — common on older industrial buildings — a survey and assessment is required, and its cost and duration belong in the programme from the start.

> 2 · HOW MUCH LIFE IS LEFT IN THE WATERPROOFING?
>
> This is the question that most often turns a good project into a bad one, and it is routinely skipped because the roof is not leaking today.
>
> An array is designed to operate for around twenty-five years. If the membrane beneath it has ten years of life remaining, then at year ten the array must be removed, the roof replaced, and the array reinstalled — at a cost that can be a substantial fraction of the original installation, plus lost generation, plus the risk of damage in handling.
>
> **Establish the membrane type, its age, its condition and its remaining life before committing.** Where the answer is materially less than the array life, the honest options are to re-roof first — which is often the right decision, since the access is never cheaper than when the roof is empty — or to accept and price the future removal and reinstatement explicitly in the case.

3 · How will it be fixed, and what does that do to the waterproofing?

Method	How it works	Consequences
Ballasted	Mounting frames held by weight, no penetrations	No holes in the membrane, but significant added load. Requires a structure with capacity and a roof surface that tolerates the point loads. Protection layers between frame and membrane are essential
Mechanically fixed	Fixings through the roof build-up into the structure	Much lighter, but every penetration is a potential leak and must be detailed and installed by someone competent in that membrane system
Adhered or welded	Mounts bonded or welded to the membrane itself	No penetrations and low weight, but membrane-specific and dependent on the membrane's own condition and remaining life
Standing-seam clamps	Clamped to the seams of a metal roof	No penetrations, light, and often the best answer on profiled metal — subject to the sheet's condition, fixings and pull-out capacity

Whichever is used, one requirement is constant: **establish before the works whether the roof carries a warranty, and what the installation does to it.** Many membrane warranties are void unless the work is performed by an approved contractor to the manufacturer's detail. Discovering that afterwards is expensive.

4 · What shades it, now and in twenty years?

Shading is not proportional. Depending on the electrical arrangement, a small shadow can disproportionately reduce the output of a whole string. A survey must record:

- Everything on the roof — plant, flues, lift overruns, parapets, aerials, lightning protection — with heights
- Surrounding buildings, structures and trees, and the shadows they cast across the year, not only on the day of the visit
- **Anything planned** — a neighbouring development, a future extension, or trees that will grow
- Inter-row shading between the array's own rows, which sets the spacing and therefore the capacity that actually fits

5 · Can it be reached, maintained and worked on safely?

- Permanent safe access to the roof, and fall protection appropriate to the work
- Walkways and clear routes for maintenance without walking on modules or membrane
- Access to everything else on the roof that already needed maintenance — an array that encloses an air handling unit creates a problem for a different trade
- A route by which modules and inverters can be delivered and, eventually, removed

6 · What is under the roof?

The occupancy beneath affects the fire strategy, the insurer's position and the acceptable arrangement. A warehouse storing combustible goods, a public building, or a process with its own hazard each change the conversation in Section 06. Establish it early — it is the kind of constraint that is easy to accommodate in design and impossible to accommodate afterwards.

ROOF SURVEY OUTPUTS TO CARRY INTO THE TENDER

- Structural assessment with the permissible additional load and the fixing method it assumes
- Membrane type, age, condition, remaining life and warranty position
- Marked-up roof plan showing all obstructions, perimeter zones and usable area
- Shading assessment across the year, including planned changes
- Access, fall protection and maintenance route requirements
- Occupancy below, and any hazard associated with it
- Route to the point of electrical connection, with distance and cable route identified

SECTION 03

Sizing to the load, *not to the roof.*

The largest array that fits is almost never the best investment. The right one is found on a curve, and the curve requires your own data.

A proposal that begins “the roof accommodates X kilowatts peak” has answered a question nobody should be asking first. The right sequence is: establish the load, model the generation against it hour by hour, and find the size at which additional capacity stops paying.

The data required

Interval consumption	At the billing interval, for a full twelve months. Without this, self-consumption is assumed rather than calculated, and every number downstream inherits the assumption
Every line of the bills	The import price to be avoided is the full delivered price — energy, network, levies and taxes as applicable. Comparing generation against the energy component alone understates the benefit substantially
The export arrangement	Whether permitted, at what limit, and at what value. See Section 08
Operating pattern	Shifts, weekends, shutdowns, seasonal variation — the things that decide the overlap in Figure 1.1
Planned changes	New plant, electrification, expansion, a change in operating hours. An array sized to today’s load on a building about to change is sized to nothing

The sizing curve

With the load data and a modelled generation profile, the analysis is straightforward and every serious proposal should show it: **as array size increases, total generation rises in a straight line, but self-consumed generation flattens.** The first panels are consumed entirely; later ones increasingly produce surplus at midday that the building cannot absorb.

The result is a curve with a recognisable knee. Below it, additional capacity is fully valued. Above it, additional capacity is worth only the export value — and if export is restricted or unremunerated, worth very little.

> ASK FOR THE CURVE, NOT THE NUMBER
>
> **“Show me self-consumption and total generation against array size, from your model of my interval data, and mark the size you are proposing on it.”**
>
> A proposal built on the analysis can produce this immediately, because the curve is how the size was chosen. One that cannot has sized the array to the roof and calculated a yield afterwards. The distinction is visible in thirty seconds and it separates most proposals you will receive.

Where the knee sits, and what moves it

- **A high, flat daytime load** — continuous process, cold storage, data equipment — pushes the knee out and supports a large array
- **Office-hours occupancy with weekends off** brings it in sharply, because two days in seven are entirely export

- **Evening or night operation** brings it in furthest; the overlap in Figure 1.1 is small regardless of array size
- **Strong export value** flattens the penalty for exceeding the knee, and where export is well remunerated the constraint shifts to the roof and the connection
- **Zero-export connection** makes the knee absolute — generation above the site load is not merely low-value, it is curtailed and lost

Two technical decisions that follow from sizing

The inverter-to-array ratio

Arrays are commonly specified with more module capacity than inverter capacity, because modules rarely produce their rated output — the rating is measured under standard test conditions that real roofs seldom reach. A moderate excess captures more energy across the year at no additional inverter cost.

The trade is **clipping**: at the brightest moments the inverter limits output and some generation is lost. A modest amount is an efficient design choice; a large amount means the array was oversized against the inverter, or against a zero-export limit. Ask for the ratio, and for the modelled clipping loss, and satisfy yourself that the trade was made deliberately.

Orientation and row spacing

Due-south at optimal tilt maximises annual yield per kilowatt. East–west arrangements generate less per kilowatt but typically fit more capacity on the same roof — because rows can be closer without shading each other — and spread generation across the day, which usually raises self-consumption. On a flat commercial roof the east–west option is frequently the better investment even though it is the worse yield, and any proposal presenting only one arrangement has skipped a real decision.

> DO NOT LET THE CONNECTION LIMIT BE DISCOVERED LATE
>
> The size the analysis supports and the size the network will permit are different questions, and the second takes longer to answer. Begin the grid connection enquiry in parallel with the sizing work, not after it — see Section 05. A design finalised before the operator responds is a design likely to be revised.

SECTION 04

Reading a *yield estimate.*

Every proposal contains an annual generation figure. Six questions establish whether it is an engineering estimate or a sales number.

Yield estimates are produced by simulation software that models irradiation, array geometry, shading, temperature and system losses across a typical year. The software is good. The estimate is only as good as its inputs and its loss assumptions, and both are invisible in the single figure at the front of a proposal.

The six questions

1 · Where did the irradiation data come from?

Every estimate begins with a solar resource dataset for the location. Different datasets differ, sometimes materially, and a dataset drawn from a distant location or a coarse grid introduces error before any array is modelled. Ask which dataset, which reference period, and what the source's own stated uncertainty is. A proposal that cannot name its irradiation source has not been produced by anyone who understands the estimate.

2 · Is it P50, and is a P90 available?

A P50 estimate is the central expectation: the outcome that should be exceeded in roughly half of years. A P90 is a conservative figure expected to be exceeded in about nine years in ten. Both are legitimate; they answer different questions.

Use P50 for the expected case and P90 for the downside, particularly where debt service or a guarantee depends on generation. A proposal quoting only a single unlabelled figure has not distinguished them, and you should assume it is the optimistic one.

3 · What is the assumed performance ratio, and what is in it?

The performance ratio expresses how much of the theoretically available energy the system actually delivers, after all real-world losses. It is the single most useful number for comparing proposals, because it summarises the loss assumptions in one figure.

Ask for the **loss breakdown behind it**, item by item. Every credible simulation produces one. The items that should be there:

Loss	What it is, and what to check
Temperature	Modules produce less when hot, and roof-mounted modules run hotter than test conditions. Check the assumption reflects your climate and the mounting arrangement — close-mounted modules on a metal roof run hotter than a ventilated frame
Shading	Should be modelled from the actual surveyed obstructions in Section 02, not applied as a flat percentage
Soiling	Dust, pollen, salt, industrial deposition, bird fouling. Site-specific — a site adjacent to a quarry, a cement works or an unpaved yard is not the same as a clean urban roof
Snow	Relevant in most of the region. Losses depend on tilt, on how long snow persists, and on whether it slides
Mismatch	Modules in a string perform to the weakest. Affected by module binning and by shading
Cabling	DC and AC resistive losses, driven by cable sizing and run length. A long route to the connection point matters
Inverter conversion	From the manufacturer's efficiency curve at realistic loading, not the peak figure
Clipping	See Section 03. Should be stated separately, not buried
Availability	An allowance for downtime — faults, maintenance, grid outages. An estimate assuming perfect availability is not an estimate
Degradation	Output declines over life. Check whether the financial model applies it year by year or uses year-one output throughout, which overstates lifetime generation

4 · Does the model use the surveyed roof, or a rectangle?

A simulation built on the actual roof geometry, with the real obstructions, perimeter zones and row spacing, will produce a different — and smaller — array than one built on the roof's bounding dimensions. Ask to see the layout the yield was calculated from, and compare it against the survey from Section 02.

5 · What degradation is assumed, and does the financial model apply it?

Modules lose output gradually across their life, typically with a larger step in the first year and a slower annual decline thereafter. Manufacturers warrant this behaviour — see Section 07. The question here is whether the financial model reflects it. A twenty-five-year cash flow built on year-one generation throughout will overstate lifetime output, and the error compounds.

6 · Who produced it, and will they stand behind it?

A yield estimate produced by the party selling the system, with no independent check and no performance commitment, is a marketing input. Where the investment is significant or externally financed, either commission an independent yield review or require a performance guarantee that puts the estimator at risk — see Section 07.

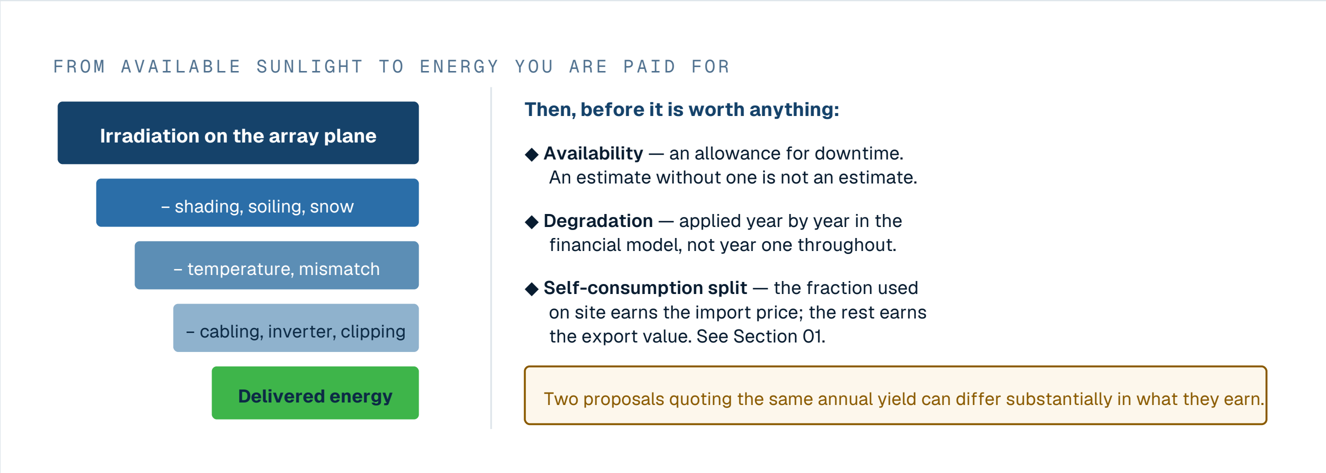


Figure 4.1 — The loss chain behind a yield figure. Ask for the breakdown, not the total. Bar widths are illustrative of the sequence, not of the magnitude of any loss.

COMPARING TWO PROPOSALS FAIRLY

Normalise before comparing. Require every tenderer to state: the irradiation dataset, whether the figure is P50 or P90, the performance ratio with its full loss breakdown, the degradation assumption and whether it is applied in the financial model, the modelled self-consumption fraction from your own data, and the array layout the yield was calculated from.

Without that, you are comparing two numbers produced under different assumptions, and the more optimistic one will look better.

SECTION 05

Electrical design *and grid connection.*

The connection process is the longest lead item on most rooftop projects and the one most often started last.

START THE CONNECTION ENQUIRY BEFORE THE DESIGN IS FINISHED

A photovoltaic array is a generator, and connecting one requires an application to the distribution system operator, a technical assessment, protection requirements, witnessed commissioning and a connection agreement. Each has its own timescale, and the operator's answer may constrain the export limit, the protection arrangement, the metering, or the permitted size — any of which sends the design back.

Apply early with a defined but not finalised proposal, and let the operator's response inform the design rather than contradict it.

What to establish with the operator

- **Whether export is permitted**, and up to what limit. Many commercial rooftop systems are configured for zero export, which is achievable but must be designed in and demonstrated at commissioning
- **The maximum generating capacity** permitted at the connection point, and whether any reinforcement would be required at your cost
- **Protection requirements** — the required functions, the settings, and whether a specific type of interface protection is mandated
- **Anti-islanding requirements**, and how they interact with any backup or storage intention. EN 50549 is the European reference for connecting generating plant in parallel with distribution networks at low and medium voltage; confirm which document actually applies where your building is, because national requirements may govern
- **Metering** — whether separate generation metering is required, who supplies it, and whether the existing import meter can register export
- **Power quality limits** at the point of connection — harmonics, flicker, voltage rise
- **Witnessing and documentation** required before energisation

Inverter architecture

Arrangement	How it works	Suits
String inverters	Several inverters, each serving a group of module strings	The commercial rooftop default. Redundancy — one failure takes out part of the array, not all of it — and straightforward replacement. Multiple roof orientations handled by separate inputs
Central inverter	One large inverter for the whole array	Larger, uniform arrays. Fewer units to maintain, but a single point of failure and a larger consequence when it fails
Module-level electronics	Optimisers or micro-inverters at each module	Roofs with unavoidable shading or many orientations, and where module-level monitoring or rapid shutdown is required. More components on the roof, and their own replacement cycle

DC design — where the specific risks live

The DC side of a photovoltaic system behaves differently from anything else in a building, and it is where most PV-specific faults originate.

- **The array is live whenever there is light**, and cannot be switched off at the modules. This governs the isolation strategy, the labelling, and the emergency arrangements in Section 06
- **DC arcs do not self-extinguish** the way alternating-current arcs do, which is why connector quality, cable support and correct termination matter more here than familiarity suggests
- **Connectors must be of the same type and manufacturer** where they mate. Mixed-brand connectors that appear compatible are a recognised failure mode and a common finding on inspections
- **Cable management** — cables supported off the roof surface and out of standing water, protected from abrasion and ultraviolet, and never left resting on the membrane
- **String protection, earthing and surge protection** designed for the array and coordinated with the building's arrangement. IEC 60364-7-712 addresses PV supply systems within low-voltage installation design; IEC 62548 addresses array design requirements
- **Lightning and surge** — an array is an extended conductive structure on the highest part of the building. The interaction with any existing lightning protection needs designing, referring to IEC 62305

Commissioning and documentation

IEC 62446 sets out documentation, commissioning tests and inspection requirements for grid-connected photovoltaic systems, and it is the right thing to name in a specification. What should be delivered:

- As-built layout showing every string, its route and its termination
- String test results — open-circuit voltage and short-circuit or operating current for every string, which is the baseline against which future faults are diagnosed
- Insulation resistance and earth continuity results
- Inverter commissioning records with the settings as applied, including any export limitation
- Protection settings as applied and as witnessed by the operator
- Verification of the export limitation function, demonstrated rather than asserted
- Thermographic survey of the array and the electrical equipment at commissioning — the single most useful diagnostic baseline the system will ever have

- Monitoring system configured, with the client's access confirmed

> CONFIRM YOU CAN SEE YOUR OWN DATA
>
> Monitoring is normally supplied by the inverter manufacturer or the installer, through their platform. Establish before contract: what data you can access, at what granularity, for how long it is retained, whether you can export it, what happens to your access if you change service provider, and whether the installer retains the ability to alter settings remotely.
>
> A system whose performance data you cannot obtain is a system whose performance you cannot dispute.

SECTION 06

Fire, safety *and insurance.*

Three conversations that arrive late, cost more than expected, and can constrain the layout after it has been designed.

A rooftop array introduces a permanently energised electrical installation on the roof of an occupied building, above whatever is stored or operated beneath it. That is manageable and routine — provided the questions are asked while the design can still change.

The fire questions

- **External fire performance of the roof.** The roof build-up's behaviour in an external fire is classified under EN 13501-5, and the array's presence forms part of the assessment. Establish the roof's classification and whether the proposed array arrangement is compatible with it
- **Array segmentation and access routes.** Firefighters need routes across the roof and access to roof lights, smoke vents and hatches. Continuous unbroken arrays covering a whole roof obstruct this, and segmentation is far cheaper to design in than to retrofit
- **Separation from openings and boundaries** — roof lights, vents, plant intakes, escape routes and site boundaries
- **Isolation and shutdown.** The array remains live in daylight regardless of what is switched. The isolation strategy, the position of isolation points, and the labelling must be designed and agreed — and the fire service must be able to establish quickly what is live and where
- **Signage and information.** Clear marking at the point of entry to the building, at the main isolation, and on the roof, identifying the presence and extent of the array
- **What is beneath.** The occupancy and storage below changes the assessment materially, and a warehouse containing combustible goods is a different case from an office

> ENGAGE THE FIRE SERVICE AND THE INSURER WHILE THE LAYOUT CAN STILL CHANGE
>
> Both will have positions, and both may impose requirements more demanding than the applicable standards — insurers in particular hold specific requirements for rooftop photovoltaic installations, and they vary between insurers.
>
> Discovering an insurer requirement after installation is expensive. Discovering that cover is restricted, loaded or unavailable is worse, and it has happened to buildings where nobody asked. **Put the question to your insurer in writing at feasibility stage**, with the proposed arrangement, the occupancy beneath and the roof construction.

Working safely on the roof, for twenty-five years

The array will be inspected, cleaned, repaired and eventually replaced. Every one of those activities requires safe access, and the arrangements must be permanent rather than assembled for each visit.

- Permanent access and fall protection appropriate to the roof and the work
- Designated walkways that do not require walking on modules or unprotected membrane
- Retained access to everything else on the roof that needs maintenance

- Competence requirements for anyone working on the DC side, which is not conventional electrical work and should not be treated as such
- A safe method for module replacement, including how a damaged module is handled while still generating

Equipment standards to name in the specification

Naming the standards in the specification is what makes the equipment comparable between tenderers rather than a matter of brand assertion.

- **IEC 61215 —** design qualification and type approval of photovoltaic modules
- **IEC 61730 —** photovoltaic module safety qualification, including the application class relevant to the installation
- **IEC 62109 —** safety of power converters for use in photovoltaic power systems, with the part addressing inverters
- **IEC 62548 —** photovoltaic array design requirements
- **IEC 60364-7-712 —** low-voltage installations, requirements for photovoltaic power supply systems
- **IEC 62446 —** testing, documentation and maintenance of grid-connected systems
- **IEC 61724 —** photovoltaic system performance monitoring
- **EN 1990, EN 1991-1-3, EN 1991-1-4 —** structural basis of design, snow actions and wind actions, for the mounting system

> ASK FOR THE CERTIFICATES, FOR THE PRODUCTS ACTUALLY OFFERED
>
> Require type test certificates and declarations for the specific module and inverter models being supplied — not for a similar model, an earlier version, or the manufacturer's range in general. Then check at delivery that what arrives matches what was certified. Substitution between tender and delivery is common, and it is legitimate only if it is disclosed and equivalent.

SECTION 07

Contract, warranties *and operation.*

Four separate warranties, three of which are commonly confused with each other — and a maintenance regime that decides whether year fifteen looks like year one.

The four warranties, and what each covers

Warranty	What it covers	What to check
Module product warranty	Defects in the module itself — manufacture, materials, workmanship	Its term, and whether it covers labour, access and shipping or only the replacement module. A free module delivered to a port is not a repaired array
Module performance warranty	That output will not fall below a stated proportion of the original rating over time, usually as a first-year step and then a slower annual decline	The retained-output figure at end of term, the measurement method in a dispute, who bears the test cost, and the remedy — replacement, additional modules, or a payment
Inverter warranty	The inverter, typically for a shorter term than the modules	The term against the array's design life — inverters are normally replaced at least once in twenty-five years, and that replacement belongs in the financial model. Check whether extension is available and at what cost
Installation and workmanship warranty	The installer's own work — mounting, cabling, terminations, roof penetrations and weatherproofing	Its term, and specifically whether roof waterproofing at penetrations is included and for how long. This is where the largest consequential losses arise and where cover is thinnest

THE COVENANT BEHIND THE PROMISE

A twenty-five-year performance warranty is worth what the entity behind it is worth in year twenty. Module manufacturers enter and leave the market; installers are frequently small companies. Establish who stands behind each warranty, whether any is insured or backed independently, and what happens if that entity ceases trading.

This is not a reason to avoid the investment. It is a reason to weight the warranty realistically in the case rather than treating it as a guarantee of twenty-five years of output.

How the work is contracted

Full EPC	One party engineers, procures and constructs, with single-point responsibility for performance. The cleanest allocation of risk and normally the right structure where the array matters commercially
Supply and install, client-designed	Cheaper, and the design risk — including yield, structural adequacy and grid compliance — sits with you. Appropriate only where you have the capability to carry it
Third-party ownership or power purchase	A provider funds, owns and operates the array; you buy the generation. No capital, and the performance risk sits with the provider. Long commitment; the price over the full term and the end-of-term arrangements must be compared honestly against ownership

Performance guarantees — what a real one contains

A performance guarantee puts the party who produced the yield estimate at risk against it. Where offered, establish:

- **What is guaranteed** — a performance ratio, or an absolute energy figure. A performance ratio guarantee is the more honest instrument, because it isolates system quality from weather
- **How it is measured** — the instrumentation, the irradiation reference, the period, and who calculates it
- **How weather is normalised**, since a dull year is nobody's fault
- **The remedy** if the guarantee is missed — repair, compensation, or additional capacity — and any cap on it
- **The exclusions** — grid outages, curtailment, shading that arose after installation, failure to perform agreed maintenance
- **The term**, and whether it survives a change of ownership of the building

Operation and maintenance

Photovoltaic systems are often sold as maintenance-free. They are low-maintenance, which is a different claim. A system with no maintenance regime will lose output steadily and nobody will notice, because there is nothing to notice against.

Activity	Typical frequency	Why
Performance review against expectation	Monthly	The core activity. Actual generation compared against modelled, weather-adjusted. Everything else is triggered by this
Visual inspection of array and mounting	Annual, or after severe weather	Damaged modules, loosened fixings, displaced ballast, cable supports, standing water
Electrical inspection and testing	Per the applicable regime	Terminations, insulation resistance, protection, earthing. String tests compared against the commissioning baseline
Thermographic survey	Periodic	Finds hot cells, failing bypass diodes and poor terminations before they become failures. Compare against the commissioning survey
Cleaning	Site-dependent	Driven by soiling rate, not by the calendar. A dusty industrial site may need it; a clean site with regular rainfall may not. Decide from monitoring data
Vegetation and shading review	Annual	Things grow, and neighbours build. The shading assessment from Section 02 is not permanent
Roof inspection beneath and around the array	Annual	The roof is now harder to see and still ageing. This is the inspection most often dropped
Inverter servicing	Per manufacturer	Filters, fans and cooling. The commonest cause of premature inverter failure is a blocked cooling path

MONITORING WITHOUT A READER ACHIEVES NOTHING

Every system is supplied with monitoring, and on most systems nobody looks at it after the first month. A gradual decline — a failed string, a soiled section, an inverter running derated — is invisible without a comparison, and a whole year can pass before anyone notices the generation is not what it was.

Specify: what the expected generation is each month, who compares actual against it, on what frequency, what deviation triggers investigation, and who is called. Half an hour a month with a chart protects the entire investment.

SECTION 08

What the business case *rests on.*

No numbers here — only the positions you must establish before any number you are shown means anything.

Rooftop solar economics are built from local conditions: the delivered import price you avoid, the value of export, the connection rules, and whatever support scheme applies. Those vary by country and they are revised. What is stable is the list of things to establish, and the order.

Establish these, in writing, before evaluating anything

Position	From	Why it decides the case
The full delivered import price, by component	Supplier and tariff document	This is what self-consumed generation avoids. Comparing against the energy component alone understates the benefit substantially
Whether export is permitted, and its value	DSO and supplier	Determines the value of everything above the self-consumption knee, and therefore the optimum array size
Any net metering or net billing arrangement	Regulator	Changes the economics fundamentally. Also the most likely thing to be revised during the array's life
Maximum permitted generating capacity at the connection	DSO	May cap the array below what the roof and the load would support
Demand charge treatment	Supplier	Solar may or may not reduce a recorded demand peak, depending on when the peak occurs. Frequently assumed and rarely checked
Support schemes, grants and tax treatment	Relevant authority	Can be decisive, and typically carries conditions and deadlines that shape the programme
Insurer position and premium effect	Insurer	Can add cost and can constrain the layout. See Section 06
Lease position, if the building is tenanted	Legal	Determines who can be sold the generation, and therefore whether it has value at all

BUILD THE CASE SO IT SURVIVES A REGULATORY CHANGE

An array whose economics depend principally on the value of exported energy is exposed to a rule that can change within its twenty-five-year life. One built principally on self-consumption is exposed only to the import price — which is far more likely to rise than fall.

Test every case against a scenario in which the export arrangement is withdrawn or materially reduced. 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

Modules, inverters, mounting	The equipment, and the mounting system the structural assessment permits
Electrical installation	DC and AC cabling, protection, switchgear modification, earthing and surge protection, metering
Structural works	Any strengthening required, and the assessment itself
Roof works	Penetration detailing, protection layers, walkways, and any re-roofing decided under Section 02
Access and safe systems	Permanent access and fall protection for the array's whole life
Grid connection	Application, assessment, any reinforcement, witnessing
Design, permitting and fire assessment	Including the fire engineering input, which is not optional and is frequently omitted from budget proposals
Recurring	Monitoring, maintenance, cleaning where required, insurance, and inverter replacement within the array's life
End of life	Decommissioning, removal and module recycling

How to present it, if it needs approving

- **Lead with the self-consumption fraction** and how it was derived from your own interval data. It is the number a sceptical reader will test first
- **Show the sizing curve** from Section 03 rather than a single proposed size, which demonstrates the size was chosen rather than offered
- **Use P50 for the expected case and P90 for the downside**, and say which is which
- **Apply degradation year by year**, and include inverter replacement within the term
- **Include the fire assessment, insurer requirements, access provision and end-of-life cost.** Their absence is the quickest way to identify a proposal that has not been thought through
- **State the export dependency explicitly**, with the scenario in which it is withdrawn
- **Separate the non-energy benefits** — emissions reporting, customer requirements, resilience, asset value — rather than folding them into the energy number

On payback claims generally. Any payback period quoted for a rooftop array depends on the site's load shape, the delivered import price, the export arrangement, the roof, and the regulatory position. A figure quoted before anyone has modelled your interval data is marketing, not engineering. Establish the self-consumption fraction first; everything after it can then be evaluated honestly.

SECTION 09

The forty-point *checklist.*

Attach it to the tender. If every box can be ticked before contract, the array will do what the paper said.

A · DEFINITION AND DATA

- ☐ Primary purpose stated — self-consumption, export, or a corporate requirement
- ☐ Twelve months of interval consumption data obtained
- ☐ Every line of the bills obtained, so the full delivered import price is known
- ☐ Operating pattern documented — shifts, weekends, shutdowns, seasonality
- ☐ Planned load changes within the array's life registered
- ☐ Lease position established where the building is tenanted
- ☐ Self-consumption fraction modelled from your own data, not assumed

B · THE ROOF

- ☐ Structural assessment completed, stating permissible load and the fixing method assumed
- ☐ Wind and snow actions assessed, with perimeter zones reflected in the layout
- ☐ Membrane type, age, condition and remaining life established
- ☐ Decision taken and priced where roof life is shorter than array life
- ☐ Roof warranty position confirmed, including approved-installer requirements
- ☐ Fixing method selected and its consequences for the membrane accepted
- ☐ Shading surveyed across the year, including planned developments and tree growth
- ☐ Permanent access, fall protection and maintenance walkways specified
- ☐ Access retained to all other roof plant
- ☐ Occupancy and storage beneath the array recorded

C · SIZING AND YIELD

- ☐ Sizing curve produced — self-consumption and total generation against array size
- ☐ Proposed size marked on the curve, with the reasoning stated
- ☐ Orientation options compared, including east–west, on investment rather than yield
- ☐ Inverter-to-array ratio stated, with modelled clipping loss
- ☐ Irradiation dataset named, with reference period and stated uncertainty
- ☐ P50 and P90 both provided and labelled
- ☐ Performance ratio stated with the full loss breakdown, item by item
- ☐ Soiling and snow assumptions justified for this specific site
- ☐ Availability allowance included
- ☐ Degradation applied year by year in the financial model
- ☐ Yield modelled from the surveyed layout, not a rectangle

D · ELECTRICAL, FIRE AND INSURANCE

- ☐ Grid connection enquiry started before the design was finalised
- ☐ Export permission, limit and any capacity cap confirmed in writing
- ☐ Protection and anti-islanding requirements confirmed with the operator
- ☐ Zero-export function specified and demonstrable, where applicable
- ☐ DC design addresses isolation, connector compatibility, cable support and surge protection
- ☐ Equipment standards named for the specific products offered, with certificates checked at delivery
- ☐ Roof fire classification confirmed compatible with the proposed arrangement
- ☐ Array segmentation, access routes and separation from openings designed in
- ☐ Fire service and insurer engaged in writing at feasibility stage

E · CONTRACT AND OPERATION

- ☐ All four warranties obtained in writing, with terms, remedies and the covenant behind each
- ☐ Commissioning pack specified — string tests, settings, export limit verification, thermographic baseline
- ☐ Monitoring access, data ownership and a named monthly reviewer agreed before contract

Project readiness sign-off

Complete and retain with the tender documents.

ROOFTOP SOLAR READINESS SIGN-OFF

Item	Name and role	Date and signature
Building and roof reference		
Modelled self-consumption fraction		
Structural assessment by		
Membrane remaining life confirmed by		
Grid connection application submitted		
Insurer position confirmed		
Checklist points 1–40 confirmed		
Released for tender by		

IF YOU CAN ONLY DO THREE THINGS

One. Model the self-consumption fraction from twelve months of your own interval data before anyone quotes a size or a payback.
Two. Establish the roof membrane's remaining life. If it is materially shorter than the array's, re-roof first or price the removal and reinstatement explicitly.
Three. Start the grid connection enquiry and the insurer conversation at feasibility stage, not after the design is fixed.

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 61215 series	Terrestrial photovoltaic modules — design qualification and type approval
IEC 61730 series	Photovoltaic module safety qualification — construction and testing requirements
IEC 62109 series	Safety of power converters for use in photovoltaic power systems, including the part addressing inverters
IEC 62548	Photovoltaic arrays — design requirements
IEC 60364-7-712	Low-voltage electrical installations — requirements for photovoltaic power supply systems
IEC 62446 series	Photovoltaic systems — requirements for testing, documentation and maintenance of grid-connected systems
IEC 61724 series	Photovoltaic system performance — monitoring, capacity evaluation and energy evaluation
IEC 62305 series	Protection against lightning
EN 50549 series	Requirements for generating plants to be connected in parallel with distribution networks, at low voltage and at medium voltage
EN 13501-5	Fire classification of construction products — classification using data from external fire exposure to roofs tests
EN 1990	Eurocode — basis of structural design
EN 1991-1-3 · EN 1991-1-4	Eurocode 1 — actions on structures: snow loads, and wind actions
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 rooftop installation specifically, the requirements of the distribution system operator, the authority responsible for permitting at the building's location, and the insurer govern above all of the above. Where they differ from anything in this guide, they prevail.

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 **Solar Energy Division** delivers rooftop and utility-scale photovoltaic projects through design, EPC and long-term operation and maintenance — including yield modelling, grid connection, commissioning to IEC 62446 and performance-ratio guarantees, from rooftop installations to multi-megawatt plant. Work is delivered under the Group's DBOM lifecycle model — design, build, operate and maintain — so that the party which produces the yield estimate is accountable for delivering it.

Prepared by the APIS Solar Energy Division · **Document** APS-GD-06 issue v1.0 of 20 August 2026 · **Contact** apisgroup.net/contact

Been quoted an array sized to your roof *rather than your load?*

Most proposals are. Our engineers will model your own interval data against a generation profile, produce the sizing curve, interrogate the yield estimate you have been given, and tell you what the array should actually be — including whether the roof beneath it will last as long.

SPEAK TO THE SOLAR ENERGY DIVISION

Self-consumption modelling and sizing · roof and structural assessment · independent yield review · grid connection · design and EPC delivery · commissioning to IEC 62446 · performance-ratio guarantees · long-term O&M and monitoring

apisgroup.net/contact · +383 49 787 233

More free guides, playbooks and checklists from APIS engineers:
apisgroup.net/guides-ebooks

APIS Ltd. · APIS sh.p.k.
Rruga Prishtinë-Lipjan km 10, Livagjë
10500 Graçanica, Republic of Kosovo
APS-GD-06 v1.0 · 20.08.2026

apis®
Building Performance