OWNER'S ENGINEER SERVICES

Your Engineer
on your side of the table

Comprehensive owner's engineer services for utility-scale power and renewable energy projects across the U.S. — solar, wind, BESS, substations and transmission — protecting performance, safety, compliance and cost from concept to commissioning.

The EPC's engineer produces the design. The lender's engineer decides whether to fund it. Neither of them works for you.

At Keentel Engineering we act as your engineering owner representative across the full project lifecycle — planning, technical specifications, design reviews, equipment procurement and factory testing, EPC oversight, commissioning and closeout. With over 30 years of industry expertise across transmission, generation and storage, we find the problems while they are still drawings, hold the contractor to the specification you actually wrote, and hand you a project that performs to its guarantees.

30+	7	8	4
YEARS ACROSS TRANSMISSION, GENERATION & STORAGE	PROJECT TYPES — SOLAR, WIND, BESS, T&D, INDUSTRIAL	ISO / RTO MARKETS PLUS THE NON-RTO FOOTPRINT	U.S. OFFICES — TAMPA, AUSTIN, SACRAMENTO, BALTIMORE

WE REPRESENT OWNERS ON | **Utility-scale solar | Wind | BESS & hybrid | HV & EHV substations | Transmission lines | Industrial power | Data center power**

WHERE WE SIT IN THE PROJECT

01	02	03	04	05	06
Develop	**Specify**	**Contract**	**Review & procure**	**Build**	**Prove & close**
Feasibility, constructability, technical risk register and independent cost review.	Owner's technical requirements, performance criteria and equipment specifications.	EPC RFP technical volume, bid evaluation and contract technical exhibits.	Design review, submittal review, factory acceptance testing and release.	Construction monitoring, non-conformance reporting and change-order review.	Commissioning, performance testing, punch list, warranty and turnover.






START A SCOPE ›› Tell us the project, the stage and what is worrying you — we return a scoped fee and schedule, and can start mid-project.

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THE ROLE, PRECISELY

Who Works for Whom

Four engineers touch the same drawings on a typical project. Only one of them is accountable to the owner's economics.

ROLE	WORKS FOR	CONTRACTUAL DUTY	WHAT THEY WILL NOT DO FOR YOU
Owner's Engineer	The owner or developer, directly — an extension of your own team	Advisory and oversight across the whole lifecycle: specification, design review, QA/QC, witnessing, non-conformance identification, optimization	Nothing — this is the only role whose remit is your outcome rather than a threshold
Independent / Lender's Engineer	Appointed by the lender, typically paid by the borrower — a structure designed to preserve impartiality	Technical due diligence, draw certifications, completion certification, performance test monitoring, annual operating reports	Optimize your design or negotiate on your behalf — the product being bought is independence
Construction Manager	The owner	Means, methods, schedule and trade coordination — a delivery role	Independent technical review of the design or the equipment
EPC's Engineer of Record	The EPC contractor	Produces and seals the design and carries professional liability for it	Review their own work adversarially, or optimize against your cost of ownership

Two different acceptance thresholds

The independent engineer works to a pass/fail bankability test — does this meet the minimum technical requirement. The owner's engineer works to your economics — is this the right design, at the right cost, with the right life. A project can satisfy the first and still be a poor asset.

Why the two roles are not held by one firm

Because independence is the product the lender is buying. An owner's engineer advocates; an independent engineer certifies. We take one seat or the other on a given project, and we say which up front.

What We Are, in One Paragraph

- **An independent electrical engineering expert representing the owner's interests** across the project lifecycle — not a design-build contractor and not a narrow subject-matter consultant.
- **Continuous rather than episodic.** Unlike a consultant brought in for a single study, we stay engaged from concept through commissioning, which is what produces continuity, accountability and alignment.
- **Technically deep on the electrical scope.** Substation and transmission design, protection and control, system studies, interconnection and NERC compliance — the areas where a defect costs the most and is hardest to see in a submittal.
- **Explicit about authority.** Whether we recommend or certify a milestone is a contractual allocation, not an assumption. We agree it in writing at the start of the engagement.

QUESTIONS WE ASK BEFORE WE TAKE THE SEAT

- Who else is reviewing this design, and to what threshold?
- Is there a lender's engineer, and are we aligned or in conflict?
- Does the contract give the owner's engineer authority, or only a voice?
- What is the delivery model — wrap, split, or owner-supplied?
- Which code editions and utility criteria actually govern?
- What are the guaranteed dates and what damages attach to them?
- Where is the measurement boundary for every guarantee?
- What has already been ordered, and can it still be changed?

NOTE There is no standard-form definition of "Owner's Engineer" in U.S. renewable energy contracting — the role is defined by the agreement. We scope it explicitly: what we review, what we witness, what we recommend, what we certify, and what remains the contractor's responsibility.

SCOPE

What We Do, Phase by Phase

And what you get at the end of each one — because an owner's engineer without named deliverables is just an opinion on a call.

PHASE	WHAT WE DO	WHAT YOU RECEIVE
Development & feasibility	Site and layout feasibility, electrical configuration options, performance assumption review, constructability risk, independent review of the cost estimate	Feasibility report, technical risk register, conceptual one-line
Permitting & interconnection support	Interconnection requirement validation, compliance roadmap against NEC, IEEE, NESC and NERC, technical exhibits for agencies and the transmission provider	Compliance matrix, permit technical exhibits, interconnection requirement register
Owner's requirements	Technical specifications, performance criteria, equipment selection guidance and interface definition — written to what you want to own, not to what is easiest to build	Owner's technical specification, equipment datasheets, interface schedule
EPC RFP & bid evaluation	Technical volume of the RFP, technical bid comparison on a like-for-like basis, contractor capability and exclusions assessment	RFP technical volume, bid tabulation and technical scoring memo
Contract support	Technical exhibit drafting, risk allocation review, guarantee and test protocol language, measurement boundary definition	Redlined technical exhibits, performance test protocols
Design review	One-lines, three-lines, protection and control, relay setting philosophy, grounding, DC and AC collection, SCADA topology, civil and structural interface	Design review comment log, compliance verification report, review disposition record
Procurement & FAT	Specification verification against quotations, submittal review, factory acceptance test witnessing, QA surveillance at the factory	FAT witness reports, deviation lists, release-for-shipment concurrence
Construction monitoring	Field inspection and installation QA, technical evaluation of change orders and RFIs, verification against the approved design	Site observation reports, non-conformance reports, monthly progress and QA report
Commissioning	Commissioning procedure review, site acceptance test supervision, relay and protection validation, SCADA and telemetry verification	Commissioning readiness review, witnessed test records, issues log
Performance testing	Capacity, energy and availability test witnessing, grid code and interconnection compliance testing, dynamic response validation against the model	Performance test report, guarantee verification memo
Completion	Documentation completeness audit, punch list development and verification, guarantee validation against the contract	Punch list, completion recommendation memo
Warranty & closeout	Warranty period technical support, O&M handover review, as-built and manual audit, end-of-warranty inspection	Turnover documentation audit, end-of-warranty inspection report

We read the contract first

Scope, completion definitions, guarantee language and test protocols decide what a review can actually achieve. Reviewing drawings without reading the agreement is guessing.

Comments are dispositioned, not sent

Every review comment is tracked to closure with the contractor's response and our acceptance or rejection recorded — and verified again in the field.

We start where you are

Most engagements begin mid-project. We baseline against the contract and the current design before offering an opinion on either.

ENGAGEMENT SHAPES Full lifecycle · Phase-specific · Design review only · Construction and commissioning only · Mid-project rescue · On-call technical advisor

THE CORE DISCIPLINE

Design Review & Technical Assurance

Every defect is cheapest at 30% design, expensive at IFC, and ruinous after energization.

What We Review

- **Single-line and three-line diagrams.** Configuration, ratings, protection zones and the coherence of the whole against the design basis.
- **Protection & control schematics.** AC and DC schematics, trip and close circuits, interlocking, lockout logic, relay I/O and CT/PT circuits.
- **Relay setting philosophy and settings.** Coordination margin, loadability, and whether the settings were derived from a fault model the transmission owner reproduces.
- **Grounding studies and grid design.** Ground potential rise, step and touch potential, and whether the fault current and clearing time used were the ones the protection design actually delivers.
- **Short circuit, load flow and coordination studies.** Assumptions, cases and equipment rating verification.
- **DC and AC collection design.** Cable sizing and ampacity, derating, losses, voltage drop and the economics behind the conductor selection.
- **SCADA and telemetry architecture.** Point lists, protocol mapping, engineering access and the ISO's data requirements.
- **Equipment specifications.** What was specified, what was quoted and what will actually be delivered — three documents that routinely disagree.
- **Interconnection studies.** Reproduced independently where the cost or schedule consequence justifies it.
- **Civil and structural interface.** Coordination and interface management with the responsible discipline.

How We Review

- **Against a written design basis.** The governing code edition, the utility's criteria and the owner's requirements are fixed first, so a comment is a deviation from an agreed standard rather than a preference.
- **With a dispositioned comment log.** Every comment tracked to closure with the contractor's response and our acceptance or rejection recorded — not a marked-up PDF returned into a void.
- **Prioritized by consequence.** Comments classified so the contractor and the owner both know which items are safety or compliance, which are cost, and which are preference.
- **At defined stages.** 30%, 60%, 90% and IFC, with the review scope and turnaround agreed in the contract so review is not a schedule excuse.
- **Closing the loop to construction.** Accepted comments verified in the field, because a comment closed on paper is not a comment closed on site.

Interface Management

- Between the array or turbines, the inverters or PCS, the collection system and the substation
- Between the plant controller, the protection system and the ISO's telemetry
- Between the electrical scope and the civil, structural and geotechnical scopes
- Between multiple contractors on a split or multi-contract delivery, where the wrap risk sits with the owner
- Between the project and the transmission owner, on requirements that change during construction

REVIEW STAGES AND TURNAROUND

STAGE	WHAT WE LOOK FOR	WHY THIS STAGE
30%	Configuration, ratings, protection philosophy, grounding basis, major equipment selection, code and criteria compliance	Everything is still cheap to change
60%	Layout, studies and their assumptions, protection scheme development, cable and equipment sizing, interface definition	The last point before procurement locks decisions in
90%	Complete schematics and wiring, settings, schedules, SCADA points, constructability and bid-package completeness	The formal comment cycle before construction pricing
IFC	Comment closure verification, revision control, and consistency across the issued set	What the crew will actually build from

STANDARDS APPLIED IEEE, NEC, NESC and NERC as adopted for the project · The utility or transmission provider's design criteria · The owner's technical specification · The interconnection agreement's technical exhibits

WHERE THE SCHEDULE IS ACTUALLY DECIDED

Procurement & Factory Testing

Long-lead electrical equipment is the critical path on most projects now. What you specify, and what you witness, decides whether it arrives right.

THE LEAD-TIME REALITY

Electrical equipment lead times run at roughly two and a half times pre-pandemic norms, with generator step-up and large substation transformers reported at two years and beyond, and high-voltage units quoted longer still. The binding constraints are grain-oriented electrical steel, copper and coil-winding labour — none of which a purchase order solves. The practical consequences for an owner:

Specify early, and specify once. A specification change after release to manufacture restarts a queue position, not a task.

Track the queue, not the promise. Manufacturing slot confirmation, not a quoted lead time, is what belongs on the schedule.

Design around what is available. Impedance, ratings and configuration can often be adjusted to a shorter-lead unit if the question is asked early enough.

Plan the spare. On critical single-transformer configurations, the spare strategy is a design decision with a lead-time answer.

Witness the tests. A transformer that fails on site is a two-year problem. Purchaser-specified factory tests are the cheapest insurance on the project.

Watch the trade landscape. Tariff and minimum-price measures now reach the PV supply chain directly, and they move.

Procurement Support

- **Technical specification and datasheets** written to the project's real requirements rather than a vendor's standard offering.
- **Quotation and technical bid evaluation** on a like-for-like basis, with exclusions and deviations surfaced explicitly.
- **Submittal and vendor drawing review** against the specification, with a dispositioned comment record.
- **Deviation management.** What the vendor is actually offering versus what was specified, and whether the difference matters.
- **Supply chain documentation support** where the project's tax or incentive position depends on sourcing evidence — coordinated with your tax and legal advisors.
- **Spare parts and strategic spares** specified while the production run is still open.

Factory Acceptance Testing We Witness

- **Power and step-up transformers.** Routine tests every unit receives, and — critically — the purchaser-specified tests that are optional unless someone asks for them: partial discharge, insulation power factor and additional impulse.
- **Switchgear and circuit breakers.** Dielectric, mechanical operation, control and interlock verification, and wiring checks against the approved schematics.
- **Inverters and power conversion systems.** Efficiency, harmonics, reactive capability, protection functions and operating range.
- **BESS containers.** HVAC and thermal management, fire detection and suppression verification, gas detection calibration, door interlocks, BMS alarm and protection logic, emergency stop chains, EMS setpoint and curtailment response, and a capacity and round-trip efficiency run.
- **Protection and control panels.** Point-to-point wiring, relay configuration and functional checks before the panel leaves the shop.
- **Release for shipment.** Our concurrence, with deviations closed or formally accepted first.

Specify the optional tests

Partial discharge, insulation power factor and additional impulse are purchaser-specified on transformers. If nobody writes them into the specification, nobody runs them.

Witness what matters most

On a constrained travel budget, the priority is the equipment with the longest replacement lead time and the tests that cannot be repeated on site.

Close deviations before shipment

A deviation accepted at the factory is a negotiation. The same deviation discovered on site is a delay with the equipment already paid for.

TEST BASIS IEEE C57 series for transformers · IEEE C37 series for switchgear and breakers · The manufacturer's type and routine test programme · The purchaser-specified tests written into the specification — which is the part most owners leave out

CONSTRUCTION PHASE

EPC Oversight & Contract Milestones

THE MILESTONE LADDER WE WORK TO

MILESTONE	WHAT IT MEANS	OUR ROLE
Mechanical Completion	Mechanically and electrically complete and capable of safe operation — but not yet interconnected or commissioned	Verification against the definition in your contract, and the punch list that comes with it
Substantial Completion	Mechanical completion plus commissioned, tested and fully interconnected. Almost always a guaranteed date with delay damages attached	Test witnessing, documentation audit and a completion recommendation supported by evidence
Commercial Operation	Placed in service and operating under the offtake and market arrangements	Performance test verification and grid compliance demonstration
Final Completion	All punch list items resolved and turnover documentation delivered	Punch list closure verification and turnover documentation audit

Whether the owner's engineer **certifies** a milestone or **recommends** it is a contractual allocation, not an industry default. We agree that in writing before the engagement starts — because a certification you thought you had, and did not, is discovered at the worst possible moment.

Construction Monitoring

- **Installation quality verification.** Against the approved drawings and the specification, not against what looks reasonable on the day.
- **Non-conformance reporting.** Written, tracked and closed — with a disposition record that survives personnel changes on both sides.
- **Change order technical evaluation.** Is the change necessary, is it the contractor's risk under the contract, and is the price consistent with the scope.
- **RFI technical review.** Fast answers where the crew is waiting, and a record of what was decided.
- **Progress verification.** Physical progress checked against the payment application, so invoicing tracks the work rather than the schedule of values.
- **Buried and concealed work.** Grounding, duct bank and foundation inspection at the only moment it can be inspected.
- **Torque, termination and cable QA.** The unglamorous items that cause the majority of first-year failures.
- **Safety observation.** Reported to the owner, without displacing the contractor's own safety responsibility.

Commercial Terms We Help You Hold

- **Delay liquidated damages** tied to a defensible completion definition rather than an ambiguous one.
- **Performance liquidated damages** against both a minimum guaranteed capacity and the higher guaranteed capacity your debt service assumes.
- **Retainage** released against verified completion, not against an invoice date.
- **Warranty scope** that covers what actually fails, with the start date tied to a milestone you can evidence.
- **Aggregate liability caps** understood in the context of what a real failure would cost to fix.

Split delivery moves the risk to you

A multi-contract or owner-supplied-equipment structure removes the EPC's margin stack and preserves your relationship with the technology supplier — but it transfers the interface and wrap risk onto the owner. That is precisely the risk an owner's engineer exists to manage, and it is the structure where the role pays for itself most obviously.

Full-wrap turnkey EPC

Split BOP plus owner-supplied equipment

Multi-contract delivery

Owner-managed construction

NOTE U.S. utility-scale renewable EPC contracting is dominated by bespoke, negotiated agreements rather than standard forms. We work to the contract you actually have, and we read it before we start.

PROVING IT WORKS

Commissioning & Acceptance Testing

THE COMMISSIONING LEVELS

L1
Factory

Component and factory verification — the equipment matches specification and works in isolation.

L2
Installation

Torque, terminations, wiring, alignment and configuration checked against the approved design.

L3
Start-up

Individual system energization and functional testing under real conditions.

L4
Integrated

All systems operating together, exposing interdependencies and cascading failure modes.

L5
Operational

Full-load and simulated-failure testing to prove operational readiness before handover.

The L1–L5 convention comes from data center practice and is increasingly applied to generation, storage and substation projects. It is an industry convention rather than a formal standard — which is exactly why the levels, the entry and exit criteria and the witnessing obligations belong in your contract in writing.

Electrical Acceptance & Commissioning

- **ANSI/NETA acceptance testing.** Field acceptance testing to the current acceptance testing specification — whose latest edition added dedicated sections for **battery energy storage systems** and **solar photovoltaic systems**, which is new and directly relevant to renewable projects.
- **ANSI/NETA commissioning specification.** The electrical commissioning standard covering low, medium and high voltage systems, with sections addressing PV and uninterruptible supplies.
- **Protection and relay validation.** Settings verified as loaded, functional trip testing, and end-to-end scheme testing with the utility where the scheme requires it.
- **SCADA and telemetry verification.** Point-by-point verification that what the plant reports is what the market and the operator receive.
- **Energization and first-synchronization support.** Sequencing, readiness review and witness attendance.
- **Commissioning documentation.** Procedure review before the fact, witnessed records during, and an issues log that closes.

The Commissioning Deliverable Chain

- Owner's project requirements — what the asset must do
- Basis of design — how the designer proposes to achieve it
- Commissioning plan and responsibility matrix
- Design and submittal review reports
- Installation and construction checklists
- Functional and integrated test procedures
- Issues log, tracked to closure
- Systems manual and training records
- Final commissioning report
- End-of-warranty review

Readiness review beats a failed test

Most commissioning delays are not test failures — they are tests attempted before the plant, the documentation or the utility was ready. A formal readiness review before each major test is the cheapest schedule protection available.

- Commissioning plan and responsibility matrix review
- Procedure review before each major test
- Readiness review and go/no-go
- Witness attendance and signed records
- Issues log tracked to closure
- Relay settings verified as loaded
- End-to-end scheme testing with the utility
- Telemetry verified point by point

SCOPE NOTE Commissioning agent, fire protection and specialist testing services are performed by the appropriate qualified parties. Keentel provides the owner's electrical engineering oversight, procedure review, witnessing and acceptance recommendation.

WHERE GUARANTEES ARE WON OR LOST

Performance Testing & Guarantees

The test protocol is negotiated years before the test is run. That is the moment to get it right.

TECHNOLOGY	TEST BASIS	WHAT IT PROVES	WHERE OWNERS GET CAUGHT
Solar PV	ASTM capacity test method with its companion reporting-conditions practice; IEC monitoring and power performance index standards, the latter reissued in 2025	Whether the plant is the size it was sold as, corrected to reporting conditions	Filtering rules and valid-point counts that quietly move the answer; and bifacial, high DC:AC and clipping cases the older methods handled poorly
Solar PV energy	IEC energy evaluation method	Whether it produced the energy over a period, against a model	Confusing a capacity test with an energy test — they answer different questions
Wind	IEC power performance measurement, current edition 2022, with the required uncertainty assessment; and the availability standard	Measured power curve and derived annual energy production, with uncertainty stated	Uncertainty treated as a footnote rather than as part of the pass criterion
BESS	IEC unit parameters and test methods, the IEC application and performance testing specification, and the IEEE test procedures standard covering type, production, installation and commissioning tests	Capacity, round-trip efficiency, response time, ramp rate and availability at defined conditions	The measurement boundary — see below. This is the single most expensive detail on a storage project
Electrical systems	ANSI/NETA acceptance testing specification, current edition	That the installed electrical equipment is fit to energize	Testing scope reduced to save schedule, then discovered missing at handover

THE STORAGE GUARANTEE TRAP

Guaranteed at the Battery. Sold at the Meter.

Suppliers typically guarantee capacity and round-trip efficiency at the **DC battery terminals**. The owner's revenue is measured at the **point of interconnection**. Every loss between the two — the converter, the step-up transformer, the collection cable — accumulates against the owner with no contractual recourse unless the measurement boundary was defined in the agreement. The related traps:

Auxiliary load excluded. HVAC, fire systems and controls run continuously and are often outside the guaranteed efficiency figure.

Throughput guarantees ignore the duty cycle. Frequency regulation and energy shifting degrade cells differently; a total-energy guarantee covers neither properly.

Round-trip efficiency varies with C-rate. A figure quoted at one rate does not hold at another.

Availability is a bigger number than it looks. Moving a guarantee from 98% to 97% adds roughly ninety hours of downtime a year.

Calendar ageing starts at the factory. Shipping and storage delays consume capacity before commercial operation, permanently.

Augmentation assumptions. What triggers augmentation, who pays, and whether the electrical provisions exist to install it.

We write measurement boundaries, test conditions, duty cycles and correction methods into the performance test protocol at contract stage — when they are a paragraph, rather than at test stage, when they are a dispute.

- Test protocol drafted at contract stage
- Measurement boundary defined explicitly
- Correction method and reporting conditions agreed
- Valid-data filtering rules written down
- Weather and irradiance instrumentation specified
- Retest rights and cure periods defined
- Duty cycle stated for storage guarantees
- Uncertainty treated as part of the criterion

NOTE Standard designations are shown without version suffixes because editions change. The applicable test standard and edition are confirmed and named in the contract for each project.

BEFORE THE MONEY MOVES

Technical Due Diligence

For owners, acquirers and boards — and for developers who would rather find the problem before the lender's engineer does.

What a Technical Package Covers

- Technology and equipment review, including bankability and supplier standing
- Energy yield and performance assumptions, and the basis behind them
- Site, geotechnical and civil assumptions
- Electrical design and studies review
- Interconnection status, requirements and cost exposure
- Contract review — EPC, supply, O&M and offtake technical terms
- Construction status, schedule realism and remaining scope
- Budget and contingency adequacy against the remaining technical risk
- Operations, maintenance and lifecycle cost assumptions
- Conclusions with conditions and recommended remediation

Why owners commission their own diligence

Technical gaps do not stay technical. They reduce debt sizing, widen credit spreads, delay conditions precedent and create capital holdbacks. Finding them first is cheaper than answering them under a financing timetable.

What Reviewers Actually Flag

- **Energy yield.** Single-source meteorological data with no cross-validation; generic degradation rates not matched to the actual cell technology; flat soiling assumptions with no site justification; availability assumptions that contradict the O&M contract.
- **Geotechnical and structural.** Wide-area soil mapping substituted for site-specific borings; table wind loads applied to trackers without dynamic analysis; galvanizing specifications not justified by measured soil corrosivity.
- **Electrical.** DC collection voltage drop beyond the design limit without justification; storage layouts that do not respect thermal runaway clearance requirements; conductor ampacity not derated for the actual site temperature.
- **Interconnection.** Missing protection coordination and breaker timing studies; deviations between the design drawings and the utility's facilities study on transformer impedance or breaker scheme.
- **Equipment and contracts.** Equipment without bankability documentation; O&M agreements silent on specialized equipment; warranty terms that do not align with the performance guarantees.
- **Documentation.** An as-built record that does not match the plant, which is discovered during the first outage rather than during diligence.

WHO COMMISSIONS THIS WORK

Developers preparing for financing	Acquirers of operating or under-construction assets	Lenders and tax equity investors	Utilities acquiring third-party projects
Boards approving capital	Insurers assessing storage risk	Owners disputing performance	Sellers preparing a data room

WHAT MAKES A DATA ROOM DEFENSIBLE

- **Studies that match the drawings.** The short circuit, coordination and grounding studies reflect the configuration actually being built, at the ratings actually ordered.
- **Interconnection documents that reconcile.** The facilities study, the agreement and the design agree on impedance, breaker scheme and protection requirements.
- **Test records that exist.** Factory acceptance records, commissioning records and settings files, complete and retrievable rather than referenced.
- **Assumptions with a stated basis.** Degradation, soiling, availability and ambient assumptions traceable to site data or a named source.
- **Contracts that align.** Performance guarantees, O&M scope and warranty terms that reference the same measurement boundary and the same duty cycle.
- **As-builts that match the plant.** Because the first outage will find out.

SCOPE NOTE Keentel provides owner-side technical review. Where a project requires an independent engineer appointed by and reporting to a lender, that is a separate role with separate independence obligations — and we will say so rather than take both seats.

WHAT IS ACTUALLY THREATENING PROJECTS IN 2026

The Risk Landscape

Interconnection Is the Dominant Schedule Risk

- **The queues are enormous and slow.** Well over two terawatts of generation and storage sit in active interconnection queues nationally, with a median time from request to commercial operation now exceeding five years for projects reaching completion.
- **Most requests never energize.** Historically only a small minority of requested capacity reaches commercial operation; the large majority withdraws.
- **Hundreds of gigawatts hold agreements but have not been built** — which means an executed interconnection agreement is not the finish line it is often treated as.
- **The mix has shifted.** Solar, storage and wind requests declined year over year while natural gas requests rose sharply — a change in competitive position for the projects still in the queue.

Equipment and Labour

- **Electrical equipment is the critical path.** Switchgear, substation transformers and generator step-up units are all quoted well beyond a year, with the largest units running to two years and more.
- **Craft labour is tightening.** A large share of the construction workforce reaches retirement age within the decade, electrician and line worker openings substantially exceed the pipeline, and wages are rising accordingly — with acute regional constraints in the Southeast.
- **Both change how a project should be sequenced** and specified, and both are knowable early enough to design around.

Compliance and Safety Expectations

- **Reliability obligations now attach to smaller resources.** Inverter-based resource registration reached down below the traditional bulk system threshold in 2026, and ride-through and event mitigation obligations reach enforcement in late 2026.
- **Interconnection performance requirements are being adopted market by market** rather than by a single federal rule, so the governing requirement is project-specific and moving.
- **Storage fire code expectations have tightened,** with hazard mitigation analysis becoming the default and testing expectations expanding — while adoption of the newest edition lags unevenly across jurisdictions.
- **Insurers now underwrite storage on documentation** — battery management records, thermal management protocols, test results, emergency response plans and maintenance evidence.

Commercial and Supply Chain

- **Sourcing rules now have cost thresholds** that projects must meet and evidence, creating a documentation workstream that did not exist before.
- **Trade measures reach the PV supply chain directly,** including minimum import price mechanisms — and they move faster than procurement cycles.
- **Data center demand is reshaping co-location,** with behind-the-meter storage increasingly used to accelerate grid connection and a rising volume of storage asset transactions.

Risk that is knowable early

Lead times, interconnection position, code adoption and labour availability are all knowable at development stage. Most schedule failures come from not asking.

Risk that changes mid-project

Interconnection requirements, reliability standards and fire code editions all move during a multi-year build. Someone has to be watching them on your behalf.

Risk that only shows up at the end

Performance shortfalls, documentation gaps and as-built mismatches surface at handover, when the leverage has already moved to the contractor.

- Interconnection position and cost exposure
- Long-lead equipment slot confirmation
- Code and standard editions in force
- Craft labour availability by region
- Sourcing documentation for incentives
- Trade measures on imported equipment
- Fire code adoption by the local AHJ
- Insurer documentation expectations

AS OF August 2026. Figures and positions in this section are drawn from public industry and government reporting and are provided for orientation. They are checked against current sources at the start of each engagement rather than assumed to hold.

THE BUSINESS CASE

Where the Role Pays for Itself

Defects caught early

A protection scheme corrected at 30% design is a comment. The same correction after panels are built is a change order; after energization it is an outage.

Specifications that hold

The purchaser-specified factory tests, the measurement boundary and the completion definitions are all free at contract stage and expensive to add later.

Interfaces owned

On split delivery the gaps between contracts are the owner's risk by default. Someone has to hold them deliberately.

TEN FINDINGS WE LOOK FOR FIRST

- **Settings derived from the wrong fault model.** Relay settings the transmission owner's database will not reproduce, discovered at the settings review rather than at energization.
- **Grounding designed to the wrong fault current.** A grid sized on a clearing time the protection design does not actually deliver.
- **Ratings that drifted.** Equipment ordered to one duty and installed on a system that changed after the study.
- **Clearances and separation not respected.** Particularly on storage layouts, where the fire code drives spacing.
- **Measurement boundaries undefined.** Guarantees at the equipment terminals and revenue at the meter, with the difference unallocated.
- **Ampacity not derated for the site.** Cable sized on nominal assumptions rather than measured soil and ambient conditions.
- **Interconnection requirements changed mid-project.** A requirement adopted after contract award and not reflected in the design.
- **SCADA point lists that do not match the market's requirements.** Discovered during telemetry commissioning, when the schedule has no float.
- **Factory tests waived to save schedule.** On exactly the equipment with the longest replacement lead time.
- **As-builts that do not match the plant.** Which turns every future study, outage and modification into an archaeology exercise.

ENGAGEMENT MODELS

Full lifecycle

Concept through end of warranty as one retained scope, with a defined deliverable set and review turnaround written into the agreement.

Phase-specific

Design review only, procurement and factory testing only, or construction and commissioning only — scoped to where your team needs depth.

Mid-project intervention

A project already in construction that is drifting — verified against the contract and the design first, then brought back under control.

- Review turnaround written into the agreement
- Named deliverables per phase
- Comment classification by consequence
- Single point of contact

ASKED AT KICKOFF

Can you start mid-construction?

Yes, and most engagements do. We baseline against the contract, the approved design and the actual field condition before offering an opinion on any of them.

Will you certify milestones?

Only if the contract gives the owner's engineer that authority. Where it does not, we recommend with evidence — and we say which applies before we start.

APPLIES TO Utility-scale solar · Wind · BESS and hybrid · HV and EHV substations · Transmission lines · Industrial power systems · Data center power · Grid interconnection and NERC compliance programmes

CAPABILITY, COVERAGE AND THE FIRMS WE WORK FOR

Behind the Review

THE EXPERTISE BEHIND AN OWNER'S ENGINEER REVIEW

- Professional engineering licensure
- HV and MV substation design
- Transmission line engineering
- Protection and control systems
- Relay settings and coordination
- Grounding and lightning design
- Power system modeling and studies
- EMT and interconnection modeling
- NERC compliance programmes
- SCADA and telemetry architecture
- Arc flash and electrical safety
- Commissioning and acceptance testing

An owner's engineer review is only as good as the engineer doing it. The reason we lead with substation, protection and system studies capability is that those are the areas where a defect is least visible in a submittal and most expensive after energization.

INDUSTRY-STANDARD ENGINEERING PLATFORMS

PSCAD · PSS®E · ASPEN · PSLF · SILENT DIG · etap

MARKET COVERAGE

- **ERCOT** — Texas
- **PJM** — Mid-Atlantic & Great Lakes
- **CAISO** — California
- **SPP** — Central US
- **MISO** — Midcontinent & South
- **NYISO** — New York
- **ISO-NE** — New England
- **WECC** — Western Interconnection
- **SERC / TVA** — Southeast
- **Vertically integrated utilities**
- **Municipal & cooperative**
- **Industrial & private networks**

OUR CLIENTS

entergy · EDF power solutions · aps · AVANGRID · aypa · SIEMENS energy · octa DATA CENTER · PIKE ENGINEERING · RRC · FISHER ASSOCIATES · BRASSWATER · RISK WORK

Documents we routinely review

Single-line diagrams, protection and control schematics, relay setting philosophy, grounding studies, short circuit and load flow studies, SCADA architecture, equipment specifications and interconnection studies.

Standards we review against

IEEE, NEC, NESC and NERC as adopted for the project, plus the utility or transmission provider's own design criteria and the owner's technical specification.

How we report

Dispositioned comment logs, witness reports, non-conformance records, monthly progress and QA reports, and completion recommendation memos with the evidence attached.

NOTE Client marks are shown to identify organizations Keentel Engineering has provided services to. Keentel is independent of, and not affiliated with, endorsed by or sponsored by any of these companies.

START HERE

Four Things and We Can Scope It

The project — technology, size, location and voltage

The stage — development, contracting, design, construction or commissioning

The delivery model — full-wrap EPC, split contract or owner-supplied equipment

The concern — what is worrying you, and what decision is coming up

WHY KEENTEL ENGINEERING

01 Continuity from concept to commissioning

Not a consultant brought in for one study. The same team carries the specification, the design review, the factory tests and the acceptance — which is what produces accountability.

02 We design this work ourselves

Substations, transmission lines, protection and interconnection studies are our own practice areas — so a review is done by people who have had to make the same decisions and defend them.

03 Grid-side depth, not just plant-side

Interconnection, EMT modeling, IEEE 2800 capability and NERC compliance sit in the same team — the areas where owners are least equipped to challenge a contractor.

04 Named deliverables, not attendance

Every phase has a defined output — a comment log, a witness report, a non-conformance record, a completion memo — so the value is visible and auditable.

05 P.E.-sealed and defensible

Florida-registered firm (Reg. No. 36853) with multi-state licensure. Written to survive transmission owner, ISO, independent engineer and lender review.

06 Clear about the seat we hold

Owner's engineer or independent engineer, advisory or certifying — agreed in writing at the start, so nobody discovers the boundary during a dispute.

PRIMARY AUTHORITIES BEHIND THIS FLYER

Testing and commissioning. ANSI/NETA Acceptance Testing Specifications and the ANSI/NETA Standard for Electrical Commissioning Specifications for electrical power equipment and systems; ANSI/ASHRAE/IES Standard 202, The Commissioning Process Requirements; Building Commissioning Association best practice guidance.

Performance testing. ASTM E2848 and E2939 for photovoltaic system capacity; IEC 61724 series for photovoltaic monitoring, power performance index and energy evaluation; IEC 61400-12 series for wind power performance and IEC 61400-26 for availability; IEC 62933 series and IEEE 2030.3 for electrical energy storage test procedures.

Equipment. IEEE C57 series for transformer requirements and test code; IEEE C37 series for switchgear and circuit breakers; UL 9540 and UL 9540A for energy storage listing and fire propagation testing; UL 1741 for power conversion equipment.

Design and safety. The National Electrical Code; the National Electrical Safety Code; NFPA 855 for stationary energy storage installation; IEEE 80, 519, 1584 and the relevant IEEE application guides.

Grid and reliability. IEEE 2800 and IEEE 2800.2 for inverter-based resource interconnection and verification; NERC Reliability Standards in the PRC, MOD and FAC families; FERC Order No. 2023 and the governing ISO or RTO interconnection procedures.

Market context. Lawrence Berkeley National Laboratory interconnection queue research; published industry reporting on equipment lead times, workforce availability, trade measures and storage insurance practice.

Standard editions, market data and regulatory positions described are current as of August 2026 and are provided for orientation only. Nothing here is legal, financial or tax advice. The governing contract, code edition and standard revision in force for a given project control.

PROTECT YOUR INVESTMENT ›› contact@keentelengineering.com · 813-389-7871 · keentelengineering.com

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