

MODELING · SIMULATION · GRID COMPLIANCE

Power System Studies from first screening to energization

Interconnection, EMT, protection, facility and NERC compliance studies for utility-scale solar, wind, BESS, hybrid, data center and large-load projects at 4 kV–765 kV — modeled, sealed and defended through review.

Most interconnection delays are not analysis problems. They are model problems, data problems and review-comment problems.

Keentel Engineering builds the model the transmission owner and ISO can actually run, produces the study package a reviewer can accept without a round trip, and stays on the project through comment response, relay settings, commissioning and as-built handover. Six industry-standard study platforms, P.E. seals in multiple states, and one accountable scope from kickoff through energization.

30+	6	4–765 kV	4
YEARS ACROSS TRANSMISSION, DISTRIBUTION & RENEWABLES	STUDY PLATFORMS ACROSS THE FULL PACKAGE	VOLTAGE RANGE STUDIED AND SEALED	U.S. OFFICES — TAMPA, AUSTIN, SACRAMENTO, BALTIMORE

THE PLATFORMS OUR STUDIES ARE BUILT IN



Interconnection & Planning

Power flow, contingency, voltage and transient stability, affected system and cluster restudy, reactive and equipment sizing, network upgrade cost drivers.

Transient & Grid Compliance

EMT model usability, weak-grid and low-SCR stability, ride-through, SSCI, overvoltage, IEEE 2800, NERC PRC and MOD validation, WECC pre-COD submittal.

Protection & Facility

Short circuit and relay settings, coordination and scheme design, arc flash to IEEE 1584, IEEE 80 grounding, harmonics, DC systems and cable sizing.



START A SCOPE ›› Send your one-line, POI data and the study requirement — we return a scoped fee and schedule, and can start from a partial data set.

THE STUDY CATALOG — PART ONE

Interconnection, Stability & Transient Studies

Everything between the queue position and an approved study report — run on a base case we rebuilt and QC'd ourselves.

Interconnection & Transmission Planning

- **Power flow & steady state.** Base case construction from ISO and TO models, POI reactive capability at 0.95 leading and lagging, tap schedules and reactive device dispatch.
- **Contingency analysis (N-1, N-1-1).** Thermal and voltage screening across ISO-defined contingency sets, subsystem and monitored-element definition, AC and DC solutions.
- **Transient stability.** Three-phase and single-phase fault clearing, critical clearing time, angular separation, voltage recovery and damping assessment.
- **Voltage stability.** PV and QV curve analysis, reactive margin at the POI and on the affected system, load model sensitivity.
- **Affected system & cluster studies.** Review and restudy of feasibility, system impact and facility study results; withdrawal sensitivity and network upgrade cost drivers.
- **Reactive & equipment sizing.** Capacitor bank, reactor, STATCOM and SVC sizing; GSU and main transformer impedance and tap optimization.
- **Small-signal & sub-synchronous.** SSR screening, modal analysis, damping of local and inter-area modes.

Model Development, QA & Validation

- **Dynamic model build.** REGC / REEC / REPC generic stack, WTG type-specific models, storage state-of-charge logic, user-written OEM models, .dvr assembly and flat-run verification.
- **RMS – EMT cross-validation.** Benchmarking PSCAD against PSS®E or PSLF dynamics to reconcile results and satisfy ISO consistency checks.
- **Model conversion & equivalence.** PSS®E ↔ PSLF ↔ PowerFactory translation with documented equivalence checks.
- **MOD-026 / MOD-027 validation.** Step-response test planning, oscillography-to-model comparison, and recalibration of excitation, governor and plant control parameters.
- **Python (psspy) & EPCL automation.** Batch contingency, scenario and sensitivity engines; automated tables and reports; model QC and data-integrity scripts.

Electromagnetic Transient (EMT) Studies

- **Model usability & validation.** OEM black-box and encrypted inverter model integration, initialization, time-step and snapshot testing against ISO checklists (PJM, MISO, ERCOT, SPP, CAISO, NYISO, ISO-NE).
- **Weak-grid / low-SCR stability.** SCR, WSCR and composite SCR screening; controller stability at low short-circuit ratio; remediation by control tuning, retune or synchronous condenser.
- **Ride-through & fault recovery.** LVRT/HVRT and frequency ride-through verified against IEEE 2800, NERC PRC-024 and PRC-029; momentary cessation, recovery ramp and repeat-fault behavior.
- **Sub-synchronous interaction (SSCI/SSTI).** Screening and EMT confirmation on series-compensated and long radial EHV lines; damping assessment and mitigation design.
- **Temporary & ground fault overvoltage.** Load-rejection overvoltage, effectively grounded versus ungrounded GSU configurations, neutral treatment and surge arrester energy duty.
- **Harmonic resonance & TOV.** Frequency scans, series and parallel resonance with collector cable capacitance, filter design and transient overvoltage screening.
- **Transformer energization.** Inrush and sympathetic inrush, point-on-wave closing and pre-insertion resistor design, POI voltage dip and flicker.
- **Switching & insulation coordination.** Breaker TRV per IEEE C37.011, line and capacitor bank switching, restrike, arrester placement and energy absorption.
- **Protection performance with IBR sources.** Negative-sequence content and phase-angle behavior, distance and directional element misoperation risk, relay model coupling.
- **Grid-forming & black start.** GFM versus GFL comparison, synthetic inertia, islanded operation, cold-load pickup and BESS black-start sequencing.
- **Plant controller tuning.** POI voltage / VAR / power-factor loops, coordination with inverter local control, hunting and interaction with adjacent plants.

THE STUDY CATALOG — PART TWO

Protection, Facility & Compliance Studies

Where the interconnection turns into hardware — settings the transmission owner accepts, labels the field can use, and a compliance record that holds up.

Protection, Coordination & Settings

- **Short circuit analysis.** 3LG, LG, LL and LLG faults, series and simultaneous faults, mutual coupling on parallel EHV circuits, sub-transient through steady-state duty.
- **Line protection settings.** Distance zone reach and timing, ground and phase overcurrent, directional polarizing, load encroachment, and POTT / PUTT / DCB / DCUB scheme design.
- **Transformer & bus protection.** Differential slope and restraint, inrush and overexcitation restraint, backup overcurrent, breaker failure timing and coordination.
- **Generation POI protection.** 21 / 50 / 51 / 67 / 59 / 27 / 81 / 32 / 40 / 46 / 78 element settings for IBR and synchronous plants, anti-islanding and direct transfer trip.
- **IBR-adapted protection.** Current-limited and negative-sequence-deficient sources, memory polarization, incremental-quantity and directional element risk per IEEE 2800 and PSRC guidance.
- **Coordination studies.** Reach and time coordination with adjacent utility terminals, margin verification, and review of prior misoperations.
- **Breaker duty.** Interrupting and close-and-latch duty per IEEE C37.010, X/R and asymmetry correction, replacement or upgrade justification.
- **NERC PRC settings compliance.** PRC-023 loadability, PRC-025 generator protection loadability, PRC-026 stable power swing, PRC-027 coordination, PRC-019 coordination of controls.
- **Event & misoperation analysis.** COMTRADE playback, fault location reconciliation, root cause determination and corrective settings.

Grid Code & NERC Compliance

- **Grid code compliance.** IEEE 2800, EU RfG (2016/631) and national grid code templates for reactive capability, ride-through, ramp rate and voltage control.
- **WECC / regional model submittal.** .epc and .dyd builds to the WECC Data Preparation Manual, Master Dynamics File readiness, Area Coordinator and staff review support.
- **Pre-COD as-built submittal.** Demonstration that on-site parameterized equipment matches the cluster study baseline, with every deviation documented.
- **FAC-008 & MOD-032.** Facility ratings support, data submittals and compliance handover packages.

Substation, BOP & Facility Studies

- **Load flow & voltage drop.** Station service and auxiliary AC systems, MV and LV distribution, regulation limits and transformer tap selection.
- **Short circuit & equipment duty.** ANSI/IEEE C37 and IEC 60909 duties — momentary, interrupting and 30-cycle — with equipment rating and panel SCCR verification.
- **Arc flash, IEEE 1584-2018.** Incident energy and boundaries, PPE category, print-ready labels, and mitigation by settings, maintenance mode or bus reconfiguration.
- **Protective device coordination.** TCC curves for MV and LV breakers, fuses and relays; selectivity, ground fault coordination and arc-energy-reducing settings.
- **Grounding & ground grid, IEEE 80.** Ground potential rise, step and touch potential, conductor and rod sizing, soil resistivity interpretation and split-factor analysis.
- **Harmonics, IEEE 519.** Total demand distortion at the PCC for VFD, UPS and rectifier load; filter design for data center and industrial plant.
- **DC systems & battery sizing.** IEEE 485 and IEEE 1115 sizing, IEEE 1187 VRLA installation design, charger sizing, DC short circuit and trip-coil voltage drop.
- **Cable sizing & ampacity.** NEC, IEEE 399 and IEC 60287 sizing, derating, raceway fill, thermal analysis and cable schedules.
- **Motor acceleration & starting.** MCC and large motor starting, voltage dip, reacceleration and torque-speed verification for BOP and cooling plant.
- **Transient stability & load shedding.** Plant islanding, generator response, underfrequency and undervoltage shedding scheme design and verification.
- **Reliability & capacity planning.** N, N+1 and 2N topology assessment, availability modeling and failure-mode review for critical facilities.
- **Generator & standby sizing.** Step load acceptance, block load sequencing, paralleling and transfer scheme verification.

SIX PLATFORMS — THE RIGHT TOOL FOR THE RIGHT STUDY

The Software We Run

The platform is chosen by the question the study has to answer — and results are reconciled across platforms so they tell one consistent story.


PSCAD® / EMTDC™
ELECTROMAGNETIC TRANSIENT STUDIES

EMT modeling and interconnection studies for inverter-based plants at 69 kV–765 kV.

- Model usability, initialization and ISO checklist testing
- Weak-grid / low-SCR stability and controller remediation
- LVRT / HVRT, momentary cessation and repeat-fault recovery
- SSCI / SSTI screening on series-compensated systems
- Load-rejection and ground fault overvoltage, arrester duty
- Grid-forming versus grid-following, black start sequencing

Utility-scale solar · Onshore & offshore wind · BESS and hybrid · Large load / data center · Synchronous condensers


Siemens PTI PSS®E
STEADY-STATE & DYNAMIC STABILITY

Power flow, short circuit and stability studies for HV/EHV interconnection and transmission planning.

- Base case construction from ISO and TO models
- N-1 and N-1-1 contingency screening, AC and DC solutions
- Transient stability, critical clearing time and damping
- PV / QV voltage stability and reactive margin at the POI
- Dynamic model build, .dvr assembly and flat-run verification
- Python (psspy) automation for cluster-scale scenario sweeps

Generator interconnection · Large-load interconnection · Transmission planning · Affected system studies · Merchant & surplus service


ASPEN OneLiner®
SHORT CIRCUIT & PROTECTION

Fault studies, relay coordination and settings for HV/EHV lines, substations and generation interconnections.

- Short circuit, series and simultaneous faults, mutual coupling
- Distance, directional and scheme design — POTT / PUTT / DCB
- Generation POI protection and direct transfer trip
- Breaker duty per IEEE C37.010, X/R and asymmetry correction
- Relay database QC against the transmission owner's model
- Settings sheets, native settings files and PRC compliance matrix

Generator POI protection · Transmission line protection · Substation protection · NERC PRC compliance · Misoperation investigation


GE PSLF™
WECC POWER FLOW & DYNAMICS

Base case, dynamic model and pre-COD submittal work for Western Interconnection projects.

- WECC base case (.epc) to the Data Preparation Manual
- Dynamic model (.dyd) build with explicit GSU modeling
- Master Dynamics File readiness, flat-run and no-disturbance checks
- MOD-026 / MOD-027 validation and recalibration
- Pre-COD as-built submittal and material modification screening
- EPCL scripting for batch case setup and result extraction

CAISO & western interconnection · BESS and hybrid · Solar and wind · Pre-COD test energy · NERC MOD compliance


DigSILENT PowerFactory®
INTEGRATED RMS + EMT

One model for load flow, short circuit, harmonics, protection and stability — IEC and IEEE.

- Balanced and unbalanced load flow on meshed and radial networks
- IEC 60909, IEC 61363 and ANSI/IEEE C37 superposition methods
- RMS and EMT simulation from the same consistent model
- Harmonics and frequency scan — IEEE 519, IEC 61000, resonance
- Grid code compliance matrices mapped clause by clause
- DPL / Python scripting and QDSL user-defined controller models

International & IEC-code projects · OEM and equipment compliance · Offshore and cable-intensive systems · Independent engineer review


ETAP®
SUBSTATION, BOP & FACILITY

Arc flash, coordination, grounding and auxiliary power studies for substations, plants and data centers.

- Arc flash to IEEE 1584-2018 with print-ready labels
- Protective device coordination and arc-energy-reducing settings
- Ground grid design to IEEE 80 — GPR, step and touch
- Harmonic analysis and filter design to IEEE 519
- DC system and battery sizing — IEEE 485 / 1115 / 1187
- Motor starting, load shedding and generator / standby sizing

Collector & POI substations · Balance of plant · Data centers & critical facilities · Industrial plants · LV through 345 kV

CROSS-PLATFORM QA PSLF ↔ PSS®E ↔ PSCAD equivalence checks so steady-state, RMS and EMT results tell one consistent story — with the reconciliation documented for the reviewer.

SCOPE TO ENERGIZATION

How the Work Runs

We stay on the project past study approval — comment response, relay settings, commissioning support, as-built model updates and NERC compliance handover.

01
Scope & data

One-line, POI data and the study requirement. We return a scoped fee and schedule, and can start from a partial data set.

02
Model build & QC

Base case rebuilt, reconciled and QC'd against the TO and ISO models before a single study is run.

03
Study execution

Steady-state, dynamic, EMT and protection studies run to the governing checklist and criteria.

04
Report & seal

Assumptions, tables, plots and pass/fail criteria, written to survive review and sealed by a P.E.

05
Comment response

We defend the package with the transmission owner, ISO, independent engineer and lender.

06
Energization

Relay settings, commissioning support, as-built model updates and compliance handover.

WHAT YOU RECEIVE

- ▶ Native project files — PSCAD case, PSS® E .sav/.raw/.dyr/.con/.sub/.mon/.idv, PSLE .epc/.dyd, ASPEN case, PowerFactory .pfd, ETAP project — delivered clean and library-clean
- ▶ Study report with assumptions, contingency tables, plots, waveform evidence and explicit pass/fail criteria against every requirement
- ▶ Model usability test report prepared in the ISO's own template
- ▶ Reactive capability curve and POI compliance demonstration
- ▶ Complete relay setting sheets plus native settings files, with calculation records suitable for utility review
- ▶ Coordination plots — TCC and R-X — with margin annotated
- ▶ Arc flash results, mitigation analysis and print-ready equipment labels
- ▶ Ground grid design report to IEEE 80 with GPR, step and touch results
- ▶ NERC PRC and grid code compliance demonstration matrix
- ▶ Mitigation options with sizing — filters, arresters, PIR, synchronous condenser, control changes — and technical justification with cost drivers
- ▶ Parameter and settings record for commissioning and MOD-026/027 handover
- ▶ Review-comment response support through study approval

WHY DEVELOPERS BRING THIS TO US

Queue delays are usually data, not analysis

Most queue delays are not analytical — they are data. We rebuild, reconcile and QC the case before we run anything, so the numbers survive transmission owner review instead of generating another comment cycle.

A model the ISO can actually run

Interconnection queues are increasingly gated by EMT model quality, not by study results. We deliver a model that is correctly initialized, correctly parameterized, and documented so a reviewer can accept it without a round trip.

Protection is where it becomes hardware

We write settings the transmission owner accepts, and we defend them in review. That is usually the difference between energizing on schedule and re-issuing the package a third time.

P.E.-sealed and defensible

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

ENGAGEMENT MODELS

Fixed-scope study package

A defined set of studies against a defined milestone — scoped fee, scoped schedule, comment response through study approval included.

Owner's engineer / on-call

Retained support across a portfolio — restudy, model maintenance, review of consultant deliverables and diligence response as they come up.

Second opinion & recovery

A stalled queue position, a rejected model or a comment letter you disagree with — we rebuild, reconcile and take it back into review.

SCOPING REFERENCE

What a Project Usually Needs

A starting point, not a menu — the actual package follows the governing ISO checklist, the utility's criteria and what the comment letter asks for.

TYPICAL STUDY PACKAGE BY PROJECT TYPE

PROJECT TYPE	CORE STUDIES	PRIMARY PLATFORMS	USUAL DRIVER
Utility-scale solar / wind	Power flow & contingency, transient and voltage stability, EMT model usability, ride-through, reactive capability, POI protection	PSS® E, PSCAD, ASPEN	ISO cluster study and EMT gate
BESS & hybrid	SCR screening, GFM/GFL behavior, EMT ride-through, SoC-aware dynamics, pre-COD as-built submittal, POI protection	PSCAD, PSLE, PSS® E	Interconnection agreement milestones
Data center / large load	Large-load interconnection, campus MV topology, harmonics at the PCC, arc flash, grounding, DC systems, ride-through exposure	ETAP, PSS® E, PSCAD	Utility service agreement and Cx
Collector / POI substation	Short circuit and equipment duty, relay settings and coordination, IEEE 80 ground grid, station service and DC sizing	ASPEN, ETAP	TO settings review and IFC design
Industrial & generating plant	Load flow, motor starting, coordination, arc flash, load shedding, standby generation sequencing, cable ampacity	ETAP, PowerFactory	Safety program and plant reliability
International / IEC	IEC 60909 short circuit, grid code compliance matrix, harmonics and resonance, integrated RMS and EMT from one model	PowerFactory	National grid code and OEM compliance

ISO / RTO AND REGIONAL EXPERIENCE

PJM — EMT model guidelines, EIT

CAISO — IPE, New Resource Impl.

SERC / TVA — LGIP cluster

MISO — cluster and DPP studies

NYISO — load interconnection

BPA — model requirements

ERCOT — NOGRR282, large load

ISO-NE — model submittal

IEC / international — EU RfG

SPP — HILL / Attachment AQ-AX

WECC — DPM, MDF, pre-COD

Vertically integrated utilities

HOW WE KEEP THE NUMBERS DEFENSIBLE

Case QC before analysis

The base case is rebuilt, reconciled against the transmission owner and ISO models, and data-integrity checked before a single study is run.

Cross-platform reconciliation

Steady-state, RMS and EMT results are benchmarked against each other, and any divergence is explained in the report rather than left for the reviewer to find.

Traceable to the source

Assumptions, standards citations and pass/fail criteria are documented so a reviewer can trace any number back to the case and clause that produced it.

COMMON REASONS A PACKAGE COMES BACK

- **The model will not initialize.** Flat-run and no-disturbance checks fail in the reviewer's environment even though the case ran locally.
- **EMT and RMS disagree.** The two platforms tell different stories and nothing in the report explains the divergence.
- **Reactive capability shown at the wrong point.** Demonstrated at the inverter terminals rather than at the POI, with collector and GSU losses unaccounted for.
- **As-built no longer matches the study.** Manufacturer substitution, inverter count or reactive footprint changed and the deviation was never documented.
- **Settings written against the wrong fault current.** Relay settings derived from a source model the transmission owner's database does not reproduce.
- **Programmed parameters differ from modeled.** Ride-through and control settings as commissioned drift from the values the study assumed.

SECTORS, FOOTPRINT AND THE FIRMS WE WORK FOR

Where the Studies Land



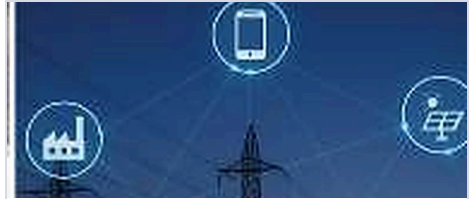
Generation Interconnection

Utility-scale solar, onshore and offshore wind, BESS and hybrid plants — feasibility through facility study, EMT and pre-COD submittal.



Substations & Transmission

Collector and POI substations, 30/60/90/IFC design support, line protection, grounding and equipment duty verification.



Data Centers & Large Load

Large-load interconnection, campus MV topology, ride-through exposure, harmonics at the PCC and L0-L5 commissioning support.



Industrial & Generating Plants

Balance of plant, auxiliary AC and DC systems, motor starting, load shedding and standby generation sequencing.



Arc Flash & Electrical Safety

IEEE 1584 incident energy studies, label programs, maintenance-mode settings and arc-energy-reducing coordination.



Owner's Engineer & Diligence

Independent engineer review, lender and diligence support, misoperation investigation and second-opinion restudy.

STANDARDS WE STUDY AND REPORT TO

IEEE 2800 — IBR interconnection

IEEE 1547 — DER interconnection

IEEE 1584 — arc flash

IEEE 80 / 81 — grounding

IEEE 519 — harmonics

IEEE C37.010 / .011 — duty, TRV

IEEE 485 / 1115 / 1187 — DC

IEEE 399 — power system analysis

NERC
PRC-019/023/024/025/026/027

NERC PRC-029 — IBR ride-through

NERC MOD-025/026/027/032

NERC FAC-008 — facility ratings

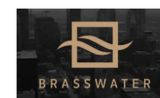
IEC 60909 / 61363 — short circuit

IEC 60287 — cable ampacity

IEC 61000 — power quality

NEC / NESC — code compliance

OUR CLIENTS



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

Three Things and We Can Scope It

1 The one-line

Single-line diagram at whatever stage it exists — concept, 30% or IFC. We can work from a partial set and tell you what is missing.

2 The POI data

Interconnection point, voltage, MW/MVA, equipment data and whatever the transmission owner or ISO has already sent back.

3 The requirement

The study requirement or the comment letter driving it. We return a scoped fee and schedule — usually within a few business days.

WHY KEENTEL ENGINEERING

01 30+ years across the whole chain

Transmission, distribution, substation and renewable experience — design and studies in the same firm, so the study reflects what will actually be built.

03 Multi-software, right tool per study

The platform is chosen by the question, not by what the office happens to own — and results are cross-validated between platforms.

05 NERC PRC and grid code fluency

PRC settings compliance, MOD model validation, FAC ratings, IEEE 2800 and regional grid code demonstration built into the deliverable.

02 One accountable scope

Studies, relay settings and design coordination sit under a single scope with one point of contact, so nothing falls between deliverables when a comment comes back.

04 P.E.-sealed, review-ready reports

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

06 We stay through energization

Comment response, relay settings, commissioning support, as-built model updates and compliance handover — not a report and a handshake.

ASKED AT KICKOFF

Can you start from a partial data set?

Yes. We scope from what exists, tell you exactly what is missing, and sequence the studies so the work that does not depend on the gap starts immediately.

Can you take over a study already in progress?

Yes. We rebuild and reconcile the case first rather than inheriting assumptions, then take the package back into review under our own seal.

Do you seal outside Florida?

Keentel is a Florida-registered engineering firm (Reg. No. 36853) with multi-state licensure and four U.S. offices. Tell us the jurisdiction and we will confirm before we scope.

Will you share your study methodology or tool setup?

No. Keentel does not share study methodologies, workflows or tool configurations. What we do share is a report where every assumption, criterion and result is documented and traceable.

START A SCOPE ›› contact@keentelengineering.com · 813-389-7871 · keentelengineering.com

NSPE

D·U·N·S REGISTERED

IEEE SENIOR MEMBER

BBB ACCREDITED A+

TAMPA — HQ

400 N Ashley Dr, Ste 2600
Tampa, FL 33602
813-389-7871

AUSTIN

5900 Balcones Dr, Ste 100
Austin, TX 78731
512-591-0752

SACRAMENTO

1401 21st St, Ste R
Sacramento, CA 95811
916-913-4524

BALTIMORE

306 W Redwood St, Ste 200
Baltimore, MD 21201
410-225-2181

contact@keentelengineering.com · keentelengineering.com · 813-389-7871 · Florida Firm Reg. No. 36853

State of Florida — Registry No. 36853, KEENTEL LLC, DBA: KEENTEL ENGINEERING · Copyright 1995–2026 Keentel Engineering. All Rights Reserved.

PSCAD and EMTDC are trademarks of Manitoba Hydro International; PSS®E is a trademark of Siemens; ASPEN OneLiner is a trademark of ASPEN Inc.; PSILF is a trademark of the General Electric group of companies; PowerFactory is a trademark of DlgSILENT GmbH; ETAP is a trademark of Operation Technology, Inc. All other marks are the property of their respective owners. Keentel Engineering is independent of, and not affiliated with, endorsed by or sponsored by any of these companies; software names identify only the analysis platforms used to produce the studies described.