

A low-angle, close-up photograph of a high-voltage electrical transmission tower. The tower's lattice structure is composed of dark metal beams, and several high-voltage power lines with insulators are visible extending from the top of the tower. The background is a clear, light blue sky.

Advanced Transmission Technologies

Attribute Matrix

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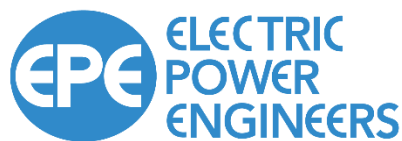
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EPE supports clients across the energy ecosystem with end-to-end solutions. Our work spans utility engineering, grid integration, regulatory compliance, and advanced analytics — delivered with the expertise needed to navigate the energy landscape. As consultants, engineers, and technologists, we act as an extension of your team, bringing over four decades of experience and a shared commitment to building a resilient, reliable, flexible, and affordable energy future.

Technology Attribute Matrix-Thermal

Technology	A. Increases Transmission Capacity	B. Increases Transmission Efficiency	C. Reduces Transmission Congestion	D. Reduces Curtailment of Generation Resources	E. Increases System Reliability	F. Increases System Resiliency	G. Increases the Capacity to Connect New Energy Generation Resources
Advanced Conductor	Yes – High. Can substantially increase line ampacity; the procedure considers overloads < 150% potentially feasible with minimal tower upgrades and 150–250% potentially feasible with tower/ROW upgrades. Above ~250%, a new line is generally more appropriate.	Yes – Moderate to High. Advanced conductors can reduce electrical losses compared with conventional conductors; DOE reports approximately 25–40% lower energy losses for advanced-conductor applications.	Yes – High. Higher transfer capability on an existing constrained corridor can relieve thermal constraints and reduce congestion, particularly where conductor ampacity is the limiting element.	Yes – Moderate to High . By increasing transfer capability across constrained corridors, advanced conductors can accommodate additional generation output that might otherwise be limited by transmission constraints. The magnitude is system- and location-dependent.	Yes – High. Provides a permanent physical increase in transmission capability and can alleviate thermal reliability constraints. DOE identifies advanced reconductoring as a potential option to support grid reliability and resource adequacy.	Yes – Moderate to High. Higher thermal capability and low-sag performance can provide additional operating margin. DOE identifies advanced-conductor deployment as a grid-resilience measure.	Yes – High. Increased corridor transfer capability can accommodate additional generation and help address transmission constraints associated with new generation interconnection, particularly when existing ROW can be reused.
Tower Lifting	Yes – Moderate to High. Most viable for loading ≤150% when ground clearance is limiting; up to ~250% may be feasible when combined with advanced conductors.	No – Not directly. Does not reduce conductor resistance or losses; primarily removes clearance/sag constraints to enable higher line loading.	Yes – Indirectly. Higher usable line rating can relieve congestion when ground clearance is the binding constraint.	Yes – Indirectly. Can reduce curtailment when generation is constrained by a clearance-limited transmission bottleneck.	Yes – Moderate. Resolves clearance-driven thermal constraints and provides a permanent increase in usable line capability but does not add a new transmission path.	Limited / Indirect. Provides additional thermal margin but does not inherently add redundancy. Implementation may also be constrained by extreme weather or height restrictions.	Yes – Indirectly. Can enable additional generation transfer when interconnection is constrained by a clearance-limited existing line .
Advanced Power Flow Controller	Yes – Moderate. Most practical for overloads up to ~ 140–150% ; higher overloads may require multiple devices, increasing cost and complexity.	Yes – Moderate. Improves utilization of existing transmission by redirecting flow from overloaded to underutilized corridors; does not inherently reduce conductor losses.	Yes – High. Directly redirects power from overloaded lines to available parallel paths, provided those paths have sufficient capacity. EPRI explicitly identifies “Congestion Reduction” as an APFC use case.	Yes – Moderate to High. By relieving transmission constraints, APFC can enable otherwise constrained generation; EPRI documents deployments that unlocked 252–400 MW of generation capacity.	Yes – Moderate to High. Controllable flow redistribution can relieve overloaded facilities and maintain reliability during contingencies/outages; however, controls and protection add operational complexity.	Yes – Moderate. EPRI identifies Operational Resilience as an APFC use case because dynamic flow control can help manage contingency events; benefits depend on available alternate paths.	Yes – High. APFC can unlock existing grid capacity through flow redistribution; DOE specifically supports APFC projects to increase transfer capacity and enable variable renewable integration .
Transmission Switching	Yes – Indirect / System-dependent. Does not increase a line’s physical rating but can increase usable network transfer capability by reconfiguring topology and shifting flow to underutilized paths.	Yes – Moderate. Can improve utilization of the existing network by finding lower-stress/lower-cost configurations; benefits depend strongly on topology and available alternate paths.	Yes – High. One of the strongest use cases: switching can reroute flow away from overloaded elements. DOE cites an SPP case where topology optimization reduced constraint flow by >20% and eliminated post-contingency overloads.	Yes – Indirectly. By relieving transmission constraints and creating alternate flow paths, switching can reduce the need for generation redispatch or curtailment; the benefit is highly system- and contingency-dependent.	Yes – Moderate to High. Can mitigate overloads and improve post-contingency performance, but every switching action must be checked to avoid creating new violations or weak/islanded conditions.	Yes – Moderate. EPRI identifies transmission switching/line switches as mechanisms that can redirect power flow and minimize outage impacts, improving system flexibility and resilience.	Yes – Indirectly. Can unlock existing network capability by relieving congestion, but it does not create new physical capacity; effectiveness depends on alternate paths and contingency performance.
Dynamic Line Rating	Yes – Moderate, weather-dependent. Best suited for ~ 110–140% of static rating ; higher gains are possible but should not be treated as firm capacity without site-specific evidence.	Yes – Moderate. Improves utilization of existing lines by replacing conservative static assumptions with actual/forecast thermal capability; it does not inherently reduce conductor losses.	Yes – Moderate to High . DOE identifies congestion management as a strong DLR benefit; better capacity forecasting can enable more efficient dispatch and reduce congestion costs.	Yes – Moderate. DLR can provide additional capacity during constrained periods and help avoid generation curtailment, especially when favorable cooling coincides with high renewable output.	Yes – Moderate. DOE states DLR can improve reliability by identifying true thermal limits, avoiding overload-related outages, and increasing situational awareness.	Yes – Moderate. DOE explicitly identifies improved reliability and resilience through enhanced situational awareness and greater operational flexibility.	Yes – Moderate. DLR can unlock existing transmission capacity and support renewable interconnection, but the available capacity is weather-dependent and not firm.

Technology Attribute Matrix-Voltage

Technology	A. Increases Transmission Capacity	B. Increases Transmission Efficiency	C. Reduces Transmission Congestion	D. Reduces Curtailment of Generation Resources	E. Increases System Reliability	F. Increases System Resiliency	G. Increases the Capacity to Connect New Energy Generation Resources
STATCOM	Moderate — Dynamic reactive support can improve voltage profiles and voltage stability limits, allowing existing transmission facilities to support higher loading where voltage, rather than thermal rating, is the limiting constraint. EPRI specifically evaluates STATCOMs for increasing transmission capacity on existing AC assets.	Moderate — By dynamically controlling reactive power and bus voltage, STATCOMs can improve power factor/voltage profiles and may reduce system losses. However, efficiency improvement is a secondary benefit rather than the primary purpose of a STATCOM.	Low to Moderate — STATCOMs do not directly reroute active power like APFCs or transmission switching. They can relieve voltage-constrained transfer limitations and thereby indirectly reduce congestion but have limited benefits when congestion is purely thermal.	Moderate — Fast dynamic voltage support can improve fault ride-through and allow generation to remain connected during voltage disturbances.	High — STATCOMs provide fast dynamic reactive power and voltage regulation, supporting transient voltage recovery and maintaining acceptable voltage performance. This directly aligns with NERC's objective of maintaining voltage and reactive resources within limits for reliable, interconnected operation.	Moderate to High — Their rapid response can help the system withstand and recover from severe voltage disturbances. However, unlike synchronous condensers, STATCOMs do not inherently provide rotational inertia or substantial synchronous fault current.	Moderate to High — STATCOMs can facilitate IBR interconnection in weak or voltage-constrained areas by providing dynamic reactive support and improving low-voltage performance/fault ride-through. The benefit is especially important where voltage stability or reactive capability limits additional interconnection.
SVC	Moderate — Dynamic reactive power and voltage support can increase usable transfer capability where voltage stability or reactive power is the limiting factor. EPRI specifically identifies “increase the transmission capacity” as one of the main reasons for applying SVCs in transmission systems.	Moderate — SVCs regulate voltage and reactive power dynamically, which can improve voltage profile and reduce reactive-power-related transmission losses. EPRI explicitly lists reduction of transmission losses as an SVC application;	Low to Moderate — SVCs do not directly control active-power routing, so they are much less direct than APFC or transmission switching for congestion management. However, by increasing voltage/stability-constrained transfer capability, they can indirectly relieve congestion when the binding constraint is voltage-related	Low to Moderate — SVCs can improve transient voltage recovery and help generation remain connected during voltage disturbances but does not directly reduce generation curtailment.	High — This is one of the strongest attributes. SVCs provide fast-acting reactive support, respond within cycles, support transient recovery, and can damp oscillations and limit voltage excursions.	Moderate — SVCs improve the ability to withstand voltage disturbances and power swings, but they do not inherently add synchronous inertia or substantial fault-current strength. They may be less effective in severely low-SCR systems, where STATCOMs or Synchronous Condensers are preferred.	Moderate — SVCs can provide dynamic reactive support needed for connecting new generation or large loads where voltage regulation is a constraint.
Synchronous Condensers	Moderate — Synchronous Condensers provide dynamic reactive power and voltage support, which can increase usable transfer capability when the system is limited by voltage stability or weak-grid conditions.	Low — Synchronous Condensers are not primarily an efficiency technology and consume real power for losses.	Low to Moderate — Synchronous Condensers do not directly reroute active power and therefore are not congestion-control technology.	Moderate — By strengthening voltage performance, short-circuit strength, and disturbance ride-through in weak-grid areas, Synchronous Condensers can reduce the likelihood that generation must trip or be restricted for stability reasons.	High — This is one of the strongest Synchronous Condenser attributes. They provide dynamic reactive power, short-circuit current, and rotational inertia, and are particularly effective in weak-grid/low-SCR areas.	High — Synchronous Condensers provide multiple physical grid-strength services simultaneously: voltage support, inertia, synchronizing torque, and fault current.	High — Synchronous Condensers can be particularly valuable for integrating new inverter-based resources in weak areas because they restore grid attributes that may diminish as synchronous generation retires.