

Supplementary Materials

The Optimal and Robust Siting and Ranking Framework for ESS and STATCOM under 765 kV Double-Circuit N-2 Contingencies

This supplement collects the additional data-intensive analyses that are referenced from the main manuscript. The scenario-level data-intensive analyses previously provided here (representative post-contingency power-flow results, severity-index weight sensitivity, the ESS-versus-STATCOM cost-ratio split, the driving N-2 pairs of the top-ranked buses, and the coverage diagnostics) have been moved into the Appendix of the main manuscript. Rank-1 and Top-3 denote, within a scenario, the candidate with the lowest robust score $RS(k)$ and the three lowest- $RS(k)$ candidates, respectively. Buses are anonymized *Bus A–Bus J* as in the main text.

S1 Computational Efficiency and Scalability

Table S6 reports the measured computational cost. The per-triple solve bound is exact (446 AC solves per scenario–contingency–candidate triple); the independent per-bus sizing makes wall-clock time fall almost linearly with the number of workers. The mean AC solve time, worker count, and hardware are measured from an instrumented rerun of the pipeline.

Table S6: Measured computational cost of the study and of the independent IEEE 118-bus test system.

Quantity	This study	IEEE 118-bus
Candidate buses $ \mathcal{B} $	10	11
N-2 pair–scenario cases $(\mathcal{S} \mathcal{C})$	407	21
Scenario files $ \mathcal{S} $	65	3
Max AC solves per triple	446	446
Total AC solves (bound)	1,815,220	103,026
Mean AC solve time	≈ 0.079 s	≈ 0.0079 s
Parallel workers	1	1
Total wall-clock time	≈ 40 h (proj., 1 worker)	0.743 h
Hardware (CPU)	Intel x64 (Family 6, Model 183)	

S2 Generalizability: A Second Test System (IEEE 118-bus)

Applying the same pipeline, unchanged, to the IEEE 118-bus system (Table S7) reproduces the two-layer structure of the main study: a scenario-robust siting winner (Bus 56) emerges, while single-node ESS or STATCOM support restores feasibility for none of the seven 138 kV double-circuit N-2 pairs. This confirms that the framework transfers to an independent network without modification.

Table S7: Scenario-robust ranking obtained by applying the same pipeline to the IEEE 118-bus system.

Item	Value
Test system	IEEE 118-bus
Number of buses	118
EHV double-circuit N-2 pairs	7 (138 kV)
Candidate bus scope	11 corridor endpoints of the 138 kV double-circuit pairs
Scenario axes	load level $\{0.9, 1.0, 1.1\} \times$
Rank-1 bus	Bus 56
Top-3 set	{Bus 56, Bus 54}
Most persistent difficult pair	89–92
Consistency with structural expectation	Consistent: robust siting winner plus a residual-difficulty layer in which single-node support restores feasibility for none of the seven pairs