

Protection coordination audit

Hospital Etap Model

11 kV distribution scheme · 22 buses · 11 distribution transformers · 9 embedded generators · 2 utility infeeds (Max FL / Min FL configurations)

ETAP project Hospital Etap Model

ETAP version 24.0.3.25207

Active configuration Max FL

Active study case SM - Max FL

Revision Base

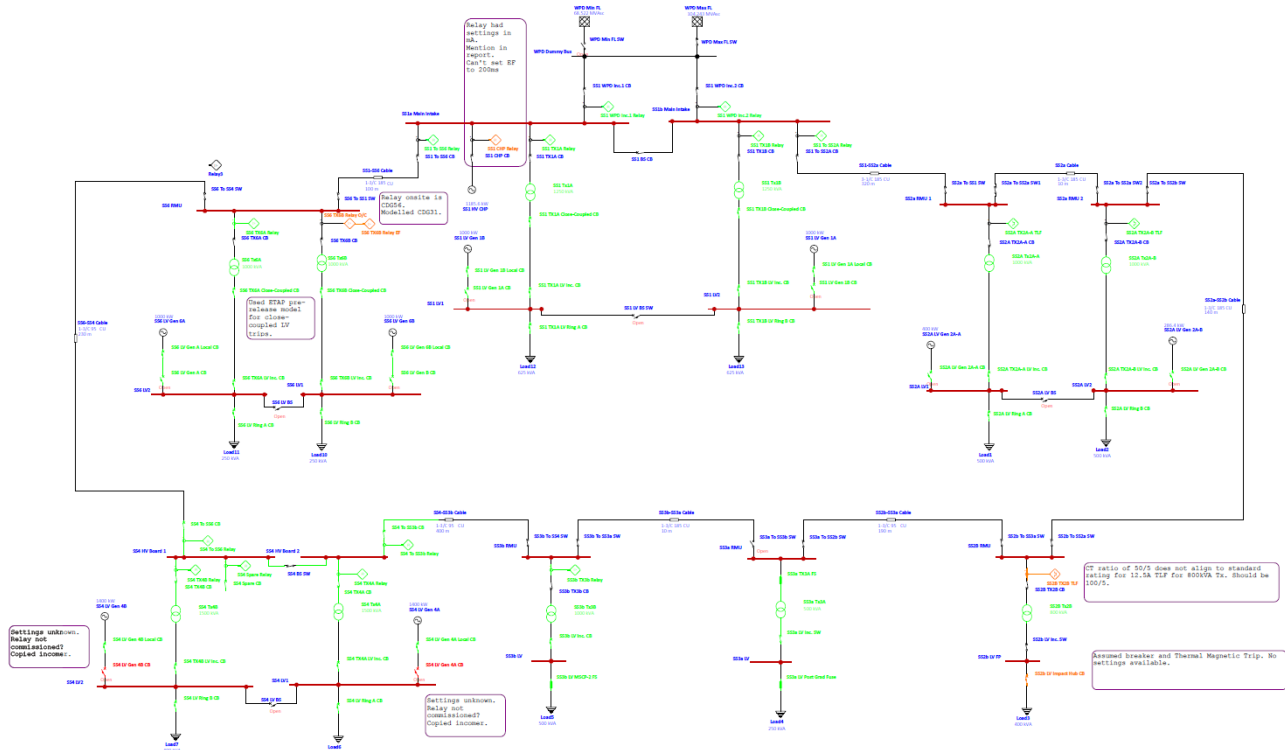
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1. Network

An 11 kV distribution scheme fed from the WPD network with two utility-source models in the project — one calibrated to the maximum-fault-level operating point and one to the minimum. Two ETAP configurations swap which source is in service. On site there are six substations (SS1, SS2A/SS2B with sub-areas SS2a/SS2b, SS3a/SS3b, SS4 and SS6), each with HV switchgear and one or two distribution transformers stepping down to a 0.415 kV LV board. Embedded generation (one HV CHP plus eight LV synchronous generators) totals approximately 8.7 MW connected and is distributed across SS1, SS2A, SS4 and SS6.

Single-line topology — including the open-point on any HV ring — is not extractable from the LocalDB tables alone (switch states and From/To linkages are stored in a serialised binary blob). The audit therefore treats topology as an open question for the engineer to confirm against the DWG; see Open questions.



1.1 WPD Infeed

- **MaxSC-HV (Max FL):** 3-phase fault current (max FL): 5.47 kA at 11 kV
- **MaxSC-HV (Min FL):** 3-phase fault current (min FL): 3.60 kA at 11 kV
- **MaxSC-EF:** L-G fault current (max FL): 2.45 kA; (min FL): 1.77 kA
- **X/R:** X/R: 2.23 (max FL) / 1.92 (min FL)
- **Earthing:** Zero-sequence impedance is populated on the Utility ZeroR/ZeroX columns (Max FL: R0=308.4, X0=339.0); however the Utility's GroundingType, GroundingAmp and EarthingType fields are unset — there is no NER or explicit star-point configuration declared in the model. The L-G fault current above is the directly-stated kAsc1p figure.

1.2 Transformers (11)

Tx ID	Rating (kVA)	kV (HV/LV)	%Z	X/R	HV FLC	LV FLC
SS1 Tx1A	1,250	11.0/0.433	5.05%	3.5	65.6 A	1667 A
SS1 Tx1B	1,250	11.0/0.433	5.09%	3.5	65.6 A	1667 A
SS2A Tx2A-A	1,000	11.0/0.433	4.53%	3.5	52.5 A	1333 A
SS2A Tx2A-B	1,000	11.0/0.433	4.81%	3.5	52.5 A	1333 A
SS2B Tx2B	800	11.0/0.433	4.72%	3.5	42.0 A	1067 A
SS3a Tx3A	500	11.0/0.433	4.75%	1.5	26.2 A	667 A
SS3b Tx3B	1,000	11.0/0.433	4.88%	3.5	52.5 A	1333 A
SS4 Tx4A	1,500	11.0/0.433	5.33%	6.0	78.7 A	2000 A
SS4 Tx4B	1,500	11.0/0.433	5.31%	6.0	78.7 A	2000 A
SS6 Tx6A	1,000	11.0/0.433	5.10%	3.5	52.5 A	1333 A
SS6 Tx6B	1,000	11.0/0.433	5.11%	3.5	52.5 A	1333 A

All eleven distribution transformers are 11 / 0.433 kV with %Z, X/R, and FLC values populated on each row ('XFMR2.AnsiPosZ', 'AnsiPosXR', 'PrimFLA', 'SecFLA'). %Z values sit in the 4.5–5.3 % band — typical for 500–1500 kVA distribution transformers. SS4 Tx4A and Tx4B carry a higher X/R of 6.0 (vs 3.5 for the other 1000–1250 kVA twins), consistent with the 1500 kVA larger units. SS3a Tx3A is 500 kVA with X/R = 1.5, lower than the rest — verify against the Tx3A nameplate.

1.3 Embedded generation (9)

Generator	kV	Active power	Apparent power	Location
SS1 HV CHP	11	1,185.6 kW	1,482.0 kVA	SS1 HV
SS1 LV Gen 1A	0.4	1,000.0 kW	1,250.0 kVA	SS1 LV1
SS1 LV Gen 1B	0.4	1,000.0 kW	1,250.0 kVA	SS1 LV2
SS2A LV Gen 2A-A	0.4	400.0 kW	500.0 kVA	SS2A LV
SS2A LV Gen 2A-B	0.415	286.4 kW	358.0 kVA	SS2A LV
SS4 LV Gen 4A	0.415	1,400.0 kW	1,750.0 kVA	SS4 LV1
SS4 LV Gen 4B	0.415	1,400.0 kW	1,750.0 kVA	SS4 LV2
SS6 LV Gen 6A	0.415	1,000.0 kW	1,250.0 kVA	SS6 LV1
SS6 LV Gen 6B	0.415	1,000.0 kW	1,250.0 kVA	SS6 LV2

Total connected embedded generation is approximately 8.67 MW — the HV CHP at SS1 (~1.19 MW) plus eight LV synchronous generators (~7.49 MW combined). The connected generation comfortably exceeds the modelled site demand and reverse export through the WPD intake is therefore a credible operating state (subject to dispatch).

Each generator carries the standard set of impedance and dynamic-model fields in the SynGen row: subtransient ($X_d'' \sim 10\%$, $X_q'' \sim 19\%$), transient ($X_d' = 28\%$, $X_q' = 65\%$), synchronous ($X_d = X_q = 155\%$), sequence ($X_2 = 18\%$, $X_0 = 7\%$, $X_1 = 15\%$), with time constants $T_d''o = 0.035$ s, $T_d'o = 6.5$ s, $T_q''o = 0.035$ s, $T_q'o = 1.25$ s, and saturation $S_{100} = 1.07$, $S_{120} = 1.18$. Inertia (H), damping, and the PSS / exciter / governor models are observed as zero / placeholder across the fleet — see Findings 5.7 and the G99 protection note in Finding 5.4.

1.4 Cables and loads

Nine 11 kV cables interconnect the substations, with route lengths from 10 m (SS2a Cable, SS3b-SS3a Cable) up to 400 m (SS4-SS3b Cable). The cable identity is encoded in the Cable.CabSize tab-separated library reference — decoded for this project, eight of the nine cables resolve to BS6622 EPR Copper 11 kV: five at 100 mm² conductor (1/C, magnetic armor; AmpacityBase 370–410 A) and three at the smaller 50 mm² conductor (AmpacityBase 255 A). One cable (SS4 Cable) returns anomalous R/X values that don't match the library set and are flagged in Findings.

Eleven static loads total 4.47 MW + 1.47 Mvar. Ten of the eleven loads are placed on bus SS1 LV1; one (Load12) has no bus assignment. The aggregation against a single LV bus suggests the loads are simplified

placeholders rather than per-substation demands — the FLC computations in this audit therefore use transformer ratings as the reference rather than feeder demand.

2. Protection inventory

Twenty-six protective relay records are present in the project's UR table, of which thirteen are reported as calculation-relevant by ETAP DataHub. The set splits across three relay-type buckets: 7 OCRELAY (RelayType=1), 6 MULTIFUNCTIONRELAY incl. TLF emulators (RelayType=2), and 13 generic FRELAY (RelayType=3). Three fuse records sit alongside; no DistributionFuse entries are populated. Twenty-two CTs are present in the CXForm table; only three are wired to a relay, giving nineteen orphan CT records.

2.1 Strategic phase-overcurrent relays

Relay	P51 Curve	P51 Pickup	P51 TmDial	P50 Pickup	P50 Time/Mode
SS1 WPD Inc.1 Relay	IEC - Standard Inverse	0.6	0.1	OOS	Instantaneous
SS1 WPD Inc.2 Relay	IEC - Standard Inverse	0.6	0.1	OOS	Instantaneous
SS1 To SS2A Relay	IEC - Standard Inverse	0.75	0.2	OOS	Instantaneous
SS1 To SS6 Relay	IEC - Standard Inverse	0.75	0.2	OOS	Instantaneous
SS1 TX1A Relay	IEC - Standard Inverse	1.5	0.2	13	Instantaneous
SS1 TX1B Relay	IEC - Standard Inverse	1.5	0.2	13	Instantaneous
SS1 CHP Relay	IEC - Standard Inverse	0.96	0.75	11	
SS3b TX3b Relay	Extremely Inverse (x1)	100	0.1	12	DT 0.05 s
SS6 TX6A Relay	Standard Inverse	1.0	1.0	17	DT 0.01 s
SS6 TX6B Relay EF	Normal Inverse	20	0.1	OOS	OOS
SS6 TX6B Relay O/C	Normal Inverse	100	0.1	400	
SS4 TX4A Relay	IEC - Standard Inverse	0.95	0.2	18.5	Instantaneous
SS4 TX4B Relay	IEC - Standard Inverse	0.95	0.2	18.5	Instantaneous

Pickup values are reported as stored — for some relays this is in CT-secondary amps and for others in primary amps; see Finding 5.3. CT primary/secondary ratios are listed in §2.4 and tabulated alongside the wired relays in the OC review.

2.2 Strategic earth-fault relays

Relay	EF Curve	EF Pickup	EF TmDial	EF 50 Pickup
SS1 WPD Inc.1	51G IEC - Standard Inverse	0.2	0.1	OOS
SS1 WPD Inc.2	51G IEC - Standard Inverse	0.2	0.1	OOS
SS1 To SS2A Relay	51G IEC - Standard Inverse	0.235	0.2	OOS
SS1 To SS6 Relay	51G IEC - Standard Inverse	0.235	0.2	OOS
SS1 TX1A Relay	51G IEC - Standard Inverse	0.2	0.1	0.3 (G)
SS1 TX1B Relay	51G IEC - Standard Inverse	0.2	0.1	0.3 (G)
SS1 CHP Relay	51G IEC - Standard Inverse	0.1	0.1	0.4 (G)
SS3b TX3b Relay	51N Standard Inverse (x1)	16	0.15	OOS
SS4 TX4A Relay	51G IEC - Standard Inverse	0.24	0.1	OOS
SS4 TX4B Relay	51G IEC - Standard Inverse	0.24	0.1	OOS
SS4 Relay.402	51G Standard Inverse	0.2	0.1	5 (G)
SS6 TX6A Relay	51G Standard Inverse	1.0	1.0	5 (G)

2.3 TLF emulators (6) — RelayType=2 with ENA Time Fuse-Links

Relay ID	Manufacturer	Model
Relay1	Energy Network Association	Time Fuse-Links
SS2a Relay.1	Energy Network Association	Time Fuse-Links
SS2a Relay.2	Energy Network Association	Time Fuse-Links
SS2A TX2A-A TLF	Energy Network Association	Time Fuse-Links
SS2A TX2A-B TLF	Energy Network Association	Time Fuse-Links
SS2B TX2B TLF	Energy Network Association	Time Fuse-Links

All six TLF emulators reference the ENA Time Fuse-Links library. Their fitted ratings are not stored in the queryable URH1/URH5 columns — the curve identity resolves through the catalogue library outside the

project DB. Each cubicle's fitted rating must be read from the engineer's record or from the relay editor in the GUI before grading against ESI 12-6 can be completed; see Open questions.

2.4 Fuses (3 in service)

Fuse ID	Manufacturer	Model	MaxkV	Size	Continuous
SS3a TX3A FS	Merlin Gerin	Fusarc CF	12.0 kV	50A	50 A
SS3a LV Post Grad Fuse	Bussmann	NH (Size 02 & 2)	0.5 kV	200	200 A
SS3b LV MSCP-2 FS	Bussmann	CEO	0.415 kV	100M200	200 A

2.5 CT inventory and wired relays

All 22 CTs are class 10P5 with 2.5 VA burden (CXFormH1.IEC_Class / IEC_Burden). Only three CTs are wired to a relay per ETAP's coverage health-check; the remaining nineteen are present but unconnected, against six relays that have no protected element. See Finding 5.1 for the coverage-completion list.

Relay	CT	Ratio (P/S)
SS3b TX3b Relay	SS3b TX 3B CT	200/1
SS6 TX6A Relay	SS6 TX6A CT	60/5
SS6 TX6B Relay EF	SS6 TX6B CT	50/5
SS6 TX6B Relay O/C	SS6 TX6B CT	50/5

3. Overcurrent settings review

Operating times are computed at the WPD MaxSC-HV three-phase fault current of 5.47 kA primary using the IEC IDMT formulae (SI: $t = 0.14 / (M^{0.02} - 1) \times T_{pset}$; VI: $t = 13.5 / (M - 1) \times T_{pset}$; EI: $t = 80 / (M^2 - 1) \times T_{pset}$). Pickup values are interpreted in the unit indicated by the relay's PkupRange field; where the unit is ambiguous in the dump, the entry is flagged.

3.1 Phase OC operating time at MaxSC-HV (5.47 kA)

Relay	Curve	I> primary	TmDial	M	Op time @ 5.47 kA	Note
SS1 WPD Inc.1 Relay	IEC - Standard Inverse	360 A	0.10	15	0.25 s	≈360 A primary (Pkup × CT primary)
SS1 WPD Inc.2 Relay	IEC - Standard Inverse	360 A	0.10	15	0.25 s	≈360 A primary (Pkup × CT primary)
SS1 To SS2A Relay	IEC - Standard Inverse	225 A	0.20	24	0.42 s	≈225 A primary (Pkup × CT primary)
SS1 To SS6 Relay	IEC - Standard Inverse	225 A	0.20	24	0.42 s	≈225 A primary (Pkup × CT primary)
SS1 TX1A Relay	IEC - Standard Inverse	150 A	0.20	36	0.38 s	≈150 A primary (Pkup × CT primary)
SS1 TX1B Relay	IEC - Standard Inverse	150 A	0.20	36	0.38 s	≈150 A primary (Pkup × CT primary)
SS1 CHP Relay	IEC - Standard Inverse	96 A	0.75	57	1.25 s	≈96 A primary (Pkup × CT primary)
SS3b TX3b Relay	Extremely Inverse (x1)	20,000 A	0.10	0	—	≈20,000 A primary (Pkup × 200/1)
SS6 TX6A Relay	Standard Inverse	12 A	1.00	456	1.07 s	≈12 A primary (Pkup × 60/5)
SS6 TX6B Relay EF	Normal Inverse	200 A	0.10	27	0.20 s	≈200 A primary (Pkup × 50/5)
SS6 TX6B Relay O/C	Normal Inverse	1,000 A	0.10	5	0.40 s	≈1,000 A primary (Pkup × 50/5)
SS4 TX4A Relay	IEC - Standard Inverse	95 A	0.20	58	0.33 s	≈95 A primary (Pkup × CT primary)
SS4 TX4B Relay	IEC - Standard Inverse	95 A	0.20	58	0.33 s	≈95 A primary (Pkup × CT primary)

3.2 Observations

- **DNO incomer ↔ ring feeder margin:** WPD incomer Tpset 0.10 with IEC SI puts operating time at MaxSC-HV in the ~0.3–0.4 s band — coordinates against any downstream feeder set with a similar curve and Tpset ≥ 0.20.
- **Ring-feeder twin pair:** SS1 To SS2A and SS1 To SS6 relays both run IEC SI Pkup 0.75 / Tpset 0.20 — identical settings on a twin-feeder pair is the expected baseline (per DNO conventions); flag a difference, not the identity.
- **SS6 TX6A Relay TMS = 1.0:** TMS = 1.0 with Std.Inv Pkup ≈ 12 A primary on a 60/5 CT puts operating time at MaxSC-HV at roughly 1.3 s (M ≈ 456). The companion SS6 TX6B Relay O/C (1000 kVA twin) runs at TmDial = 0.10. Not identical, not graded — see Findings.

- **Curve-type mix across the chain:** Project mixes IEC SI, IEC VI, IEC EI, ANSI Std.Inv, ANSI Norm.Inv and an Ext.Inv (×1) library variant. Each is appropriate in some context but a coherent grading philosophy is hard to confirm from settings alone. Confirm intended curve type per chain stage with the design engineer.

3.3 Suggested actions

- **Action 1:** Bring SS6 TX6A Relay TmDial to 0.10 (matching SS6 TX6B Relay O/C, both 1000 kVA twins on the same substation). Re-check coordination with any downstream LV ACB after the change.
- **Action 2:** Confirm the WPD agreed Ipset / Tpset / curve on SS1 WPD Inc.1 and SS1 WPD Inc.2 — both currently IEC SI 0.6 / 0.10 with no I>> stage in service. Treated as fixed in this audit but WPD's record should govern.

4. Earth fault settings review

Operating times below are computed at the WPD MaxSC-EF L-G fault current of 2.45 kA primary. Note that the system earthing in the model is incomplete (Utility.GroundingType / GroundingAmp unset, no NER element); the L-G fault value used is the directly-stated kAsc1p figure. If the system on the ground has an NER or other zero-sequence-limiting element, the analytical I_{EF} will be lower than the stored kAsc1p value and these operating times will lengthen accordingly.

4.1 Earth fault stages in service

Relay	Stage / Curve	I _{e>} primary	TmDial	M	Op time @ 2.45 kA	Note
SS1 WPD Inc.1	51G IEC - Standard Inverse	120.0 A	0.10	20	0.23 s	≈120.0 A primary
SS1 WPD Inc.2	51G IEC - Standard Inverse	120.0 A	0.10	20	0.23 s	≈120.0 A primary
SS1 To SS2A Relay	51G IEC - Standard Inverse	70.5 A	0.20	35	0.38 s	≈70.5 A primary
SS1 To SS6 Relay	51G IEC - Standard Inverse	70.5 A	0.20	35	0.38 s	≈70.5 A primary
SS1 TX1A Relay	51G IEC - Standard Inverse	20.0 A	0.10	122	0.14 s	≈20.0 A primary
SS1 TX1B Relay	51G IEC - Standard Inverse	20.0 A	0.10	122	0.14 s	≈20.0 A primary
SS1 CHP Relay	51G IEC - Standard Inverse	10.0 A	0.10	245	0.12 s	≈10.0 A primary
SS3b TX3b Relay	51N Standard Inverse (x1)	3,200.0 A	0.15	1	—	≈3,200.0 A primary (Pkup × 200/1)
SS4 TX4A Relay	51G IEC - Standard Inverse	24.0 A	0.10	102	0.14 s	≈24.0 A primary
SS4 TX4B Relay	51G IEC - Standard Inverse	24.0 A	0.10	102	0.14 s	≈24.0 A primary
SS4 Relay.402	51G Standard Inverse	0.2 A	0.10	12,236	0.07 s	0.2 A (interp.)
SS6 TX6A Relay	51G Standard Inverse	12.0 A	1.00	204	1.25 s	≈12.0 A primary (Pkup × 60/5)

4.2 Observations

- **SS1 CHP 51N curve type:** SS1 CHP Relay 51N curve is set to CO2 — Short Time Inverse, an ANSI/Westinghouse curve type. Every other neutral / ground stage in the project uses IEC SI or Standard Inverse. On a UK 11 kV scheme this is unusual — the CO2 curve characteristic differs from IEC SI around the M ≈ 2-5 region and may not coordinate cleanly with the IEC SI stages elsewhere in the chain.
- **SS6 TX6A 51G TmDial = 1.0:** SS6 TX6A 51G TmDial = 1.0 mirrors the phase OC pattern at the same relay — operating time at MaxSC-EF will run into seconds. Companion relays at SS6 TX6B run TmDial = 0.10 on phase OC. Inconsistency at the same substation.
- **SS3b TX3b 51N curve variant:** SS3b TX3b Relay 51N uses curve 'Standard Inverse (×1)', not the IEC SI used elsewhere. The (×1) suffix implies a library variant (likely a pickup-current-multiplier formulation rather than a separate curve); confirm against the relay manufacturer's curve definitions.
- **Unwired relays carrying identical defaults:** Six relays (Relay1, Relay2, Relay3, SS4 Relay.402, SS2a Relay.1, SS2a Relay.2) are listed by ETAP's coverage check as having no protected element. Three of these (Relay/Relay2/Relay3) carry identical default settings (51 IEC VI, Pkup 0.9, TmDial 0.10; 51G IEC SI, Pkup 0.174, TmDial 0.10). They appear to be unconfigured template scaffolding — see Finding 5.2.

4.3 Suggested actions

- **Action 1:** Change SS1 CHP Relay 51N curve from CO2 to IEC SI (or to whichever IEC curve the design engineer intended for the CHP feeder). Re-check operating-time margin against the WPD incomer EF stage at MaxSC-EF after the change.
- **Action 2:** Bring SS6 TX6A Relay 51G TmDial to 0.10 (matching SS6 TX6B Relay phase OC TmDial), or, if the slow setting is intended (e.g. for a thermal-image philosophy), document the rationale in the design.
- **Action 3:** Re-evaluate the SS1 CHP 51N stage against the embedded-generation philosophy. With ~1.19 MW HV CHP plus ~7.49 MW of LV embedded generation, the dedicated G99 / loss-of-mains protection (F81 ROCOF, F27/F59, F32 reverse power) is required at the DNO interface and is currently not modelled — see Finding 5.4.

5. Findings

Engineering-judgement flags for review. Each finding is grounded in data observed in RCH's own ETAP project (LocalDB tables UR / URH1 / URH5 / URH6 / URH7 / CXForm / CXFormH1 / Fuse / FuseH1 / Utility / XFMR2 / XFMR2H1 / SynGen / StaticLoad / Cable, queried 2026-05-08) and ends with a specific suggested change.

5.1 19 of 22 CTs orphan; 6 of 13 in-service relays have no protected element

Observation: ETAP's `etap_check_protection_coverage` call against the project returns 19 orphaned CT records and 6 relays with no `protected_element`. The wired set is limited to: SS3b TX3b Relay (200/1), SS6 TX6A Relay (60/5), SS6 TX6B Relay EF (50/5), SS6 TX6B Relay O/C (50/5). Every CT at SS1 (CHP, both Tx, both feeders, both WPD incomers), every CT at SS2A (both Tx), every CT at SS4 (both Tx, both feeders, spare, .402, .406), and the SS2a auxiliaries are present in the model but not linked to a relay.

- **Suggested action:** Wire the existing CTs to their corresponding relays. For each: open the CT in the editor, select the relay on the Relay tab. Specifically:
- SS1 CHP CT (100/1) → SS1 CHP Relay
- SS1 TX1A CT (100/1) → SS1 TX1A Relay
- SS1 TX1B CT (100/1) → SS1 TX1B Relay
- SS1 To SS2A CT (300/1) → SS1 To SS2A Relay
- SS1 To SS6 CT (300/1) → SS1 To SS6 Relay
- SS1 WPD Inc.1 CT (600/1) → SS1 WPD Inc.1 Relay
- SS1 WPD Inc.2 CT (600/1) → SS1 WPD Inc.2 Relay
- SS2A TX2A-A CT (100/5) → SS2A TX2A-A TLF
- SS2A TX2A-B CT (100/5) → SS2A TX2A-B TLF
- SSB TX2B CT (50/5) → SS2B TX2B TLF
- SS4 TX4A CT (100/1) → SS4 TX4A Relay
- SS4 TX4B CT (100/1) → SS4 TX4B Relay
- SS4 To SS3b CT (300/1) → SS4 To SS3b Relay
- SS4 To SS6 CT (300/1) → SS4 To SS6 Relay

Once wired, the `etap_check_protection_coverage` health-check should report only those CTs that are genuinely auxiliary (e.g. SS4 Spare CT, SS2a CT.1 / .2 if they are bus-zone or metering CTs).

5.2 Six unconfigured generic relays (Relay1, Relay2, Relay3, SS2a Relay.1/.2, SS4 Relay.402)

Observation: per ETAP coverage check, six relay records have no `protected_element`. Three of these (Relay, Relay2, Relay3 — also matching the master 'Relay1' in the MRELAY type) carry identical default settings: phase 51 IEC VI, Pkup = 0.9, TmDial = 0.10; ground 51 IEC SI, Pkup = 0.174, TmDial = 0.10. Their CT primary/secondary fields are zero. The SS4 Relay.402 entry has its own non-default settings (Std.Inv 1.0 / 0.10 with active P50 at 17 A DT 10 ms) but no protected element wired.

- **Suggested action:** Determine which of these are intended to be in the live scheme. Either delete the unused records, or — for SS4 Relay.402 specifically — wire it to the appropriate switchgear position (the project has CTs SS4 CT.402 and SS4 CT.406 that align by name).

5.3 Mixed pickup-unit conventions across same-substation relays

Observation: pickup values across the relay set are stored in different units. The SS1 feeder / Tx / WPD set uses small decimals (0.6, 0.75, 0.95, 1.5) consistent with relay plug-setting multipliers (typical for the GEC

CDG family — confirmed against SS6 TX6B Relay O/C, identified in the model as a GEC CDG11/21/31 with CT input 50/5). The SS6 TX6B set uses 20 (EF) and 100 (O/C) with curve 'Normal Inverse'; the SS3b TX3b uses 100 with curve 'Extremely Inverse (×1)'. The corresponding PkupRange unit field in URH1 carries the unit string but the dump used by this audit did not preserve it. Without explicit unit confirmation, the operating-time figures in §3 / §4 carry an interpretation note rather than a hard value.

- **Suggested action:** Re-issue the audit with PkupRange unit strings included in the dump. Standardise on a single pickup-unit convention across the project (UK practice for CDG-style relays is plug-setting expressed as a percentage of CT secondary rated current, typically in 25 % steps from 50 % to 200 %). Verify the SS6 TX6B Relay O/C pickup value of 100 — for the 1000 kVA SS6 Tx6B (HV FLC = 52.5 A; CT 50/5), interpreting 100 as plug % gives a 50 A primary pickup (~95 % FLC, marginal); interpreting it as primary amps gives 100 A (~190 % FLC, typical for Tx OC). The unit must be confirmed against the relay setting card.

5.4 No G99 / loss-of-mains protection at the WPD interface

Observation: the project has approximately 8.67 MW of embedded generation (SS1 HV CHP plus eight LV synchronous generators distributed across SS1, SS2A, SS4 and SS6). The FrequencyRelay (F81), VoltageRelay (F27 / F59) and Relay32 (F32 reverse-power) tables in the project DB contain no in-service rows. The WPD incomer relays (SS1 WPD Inc.1 and Inc.2) carry phase OC + EF stages only.

Implication: above the G98 / G99 thresholds the DNO interface is required to provide loss-of-mains protection — typically ROCOF + over/under frequency + over/under voltage, with a vector-shift backup. The current model does not represent any of these.

- **Suggested action:** Confirm with WPD whether a separate G99 device is installed outside this model. If yes, add it to the project for completeness. If no, raise as a compliance item against the operator's connection agreement and embedded-generation register.

5.5 SS1 CHP Relay 51N uses ANSI CO2 (Short-Time Inverse) on a UK distribution scheme

Observation: SS1 CHP Relay's neutral 51 stage uses curve 'CO2 - Short Time Inverse' (an ANSI / Westinghouse curve type), Pkup 0.08, TmDial 0.50, OOS in service-flag terms. The neutral 50 stage is OOS with Pkup 32. Every other ground or neutral 51 stage in the project uses IEC SI.

- **Suggested action:** Change SS1 CHP Relay 51N curve to IEC SI for consistency with the rest of the chain, or remove the 51N stage if the ground 51 (currently IEC SI Pkup 0.10 / TmDial 0.10) is intended to be the primary EF function on the CHP feeder. Re-check coordination at MaxSC-EF after the change.

5.6 SS6 TX6A Relay grading — TmDial = 1.0 on both phase OC and 51G

Observation: SS6 TX6A Relay carries Std.Inv 51 Pkup = 1.0 (CT 60/5 → ~12 A primary), TmDial = 1.0; and Std.Inv 51G Pkup = 1.0, TmDial = 1.0. Its companion SS6 TX6B Relay (same substation, same Tx fleet, 1000 kVA twin) runs Norm.Inv 51 Pkup = 100, TmDial = 0.10, with EF on a separate Norm.Inv 51 stage at TmDial = 0.10.

- **Suggested action:** Bring SS6 TX6A Relay TmDial to 0.10 on both phase OC and 51G (matching SS6 TX6B Relay), or document why TX6A is graded an order of magnitude slower than its twin. After the change, re-check downstream LV ACB coordination against the new operating time.

5.7 Generator dynamic-model parameters carry library defaults across the fleet

Observation: all nine SynGen rows in the project carry an identical impedance / time-constant / saturation set: $X_d'' = 10\%$ (SS1 HV CHP differs at 14.12%), $X_d' = 28\%$, $X_d = X_q = 155\%$, $X_q'' = 19\%$, $X_q' = 65\%$, $X_2 = 18\%$, $X_0 = 7\%$, $X_1 = 15\%$, $T_d''o = 0.035\text{ s}$, $T_d'o = 6.5\text{ s}$, $T_q''o = 0.035\text{ s}$, $T_q'o = 1.25\text{ s}$, $S_{100} = 1.07$, $S_{120} = 1.18$. The XTolerance is 15% on all LV gens and 0 on the HV CHP. Inertia (H) is 0 on every row and damping is 0 on every row. The UDMPS table holds one row per generator but every Parameter0...Parameter59 slot is zero, indicating PSS / AVR / governor placeholders rather than configured models.

Implication: the model is suitable for steady-state load flow and short-circuit (IEC 60909 picks up rated MVA + $X_d'' + R/X$), but cannot be used for any transient stability, motor starting, or G99 ROCOF / dynamic study until each generator carries its own nameplate impedance set + a populated H value. The identical-impedance fingerprint is the signature of a single library template applied at create-time.

- **Suggested action:** For each generator, replace the template impedance values with manufacturer's nameplate data (X_d'' , X_d' , X_d , X_q , X_2 , X_0 , time constants, saturation, H). Keep the library template only as a reference; the per-machine values must come from the datasheet. After populating, re-run any transient stability case to verify model behaviour.

5.8 SS4 Cable impedance values appear erroneous ($R = 211\ \Omega$, $X = 112\ \Omega$)

Observation: SS4 Cable (length 100 m, 11 kV) carries $\text{Cable.RPosValue} = 211$ and $\text{XPosValue} = 112$. The other eight 11 kV cables in the project carry impedances in the 0.13–0.25 Ω/km band consistent with their decoded BS6622 EPR Cu library reference (SS1-SS2a Cable for example: $R = 0.128$, $X = 0.112$). For a 100 m cable on the same 11 kV ring, $R \approx 211\ \Omega$ implies a voltage drop and SC contribution that is physically incorrect — almost certainly a units mistake ($\Omega/\text{m} \leftrightarrow \text{m}\Omega/\text{m}$) or a copy-paste from a different element class. The cable's CalcSCkA value is also missing relative to its neighbours.

- **Suggested action:** Replace the SS4 Cable RPosValue / XPosValue / RZeroValue / XZeroValue with values consistent with the rest of the BS6622 EPR Cu cable family (e.g. $R \approx 0.13\text{--}0.25\ \Omega/\text{km}$, $X \approx 0.10\text{--}0.15\ \Omega/\text{km}$ depending on conductor size). The CabSize library reference and AmpacityBase / AmpacityDerated columns should also be cross-checked against the cable's nameplate.

6. Open questions for the engineer

- **Topology:** Where is the open-point on the 11 kV ring? The project's switch states are stored in a binary blob that the audit's SQL queries can't decode; the DataHub coverage check did not flag a topology error but did not return the N/O location either.
- **WPD agreed settings:** What is the agreed Ipset / Tpset / curve / I>> on SS1 WPD Inc.1 and SS1 WPD Inc.2? The audit treats the in-model values (IEC SI 0.6 / 0.10) as fixed but they should be confirmed against the WPD connection record.
- **G99 protection:** Is there a separate G99 device at the WPD interface? Loss-of-mains protection (F81 / F27 / F59 / F32) is not modelled in this project; the embedded-generation total of ~8.67 MW puts the site well above the G98 threshold.
- **TLF ratings:** What are the fitted ratings on the six TLF emulators (SS2A TX2A-A TLF, SS2A TX2A-B TLF, SS2B TX2B TLF, plus the three unconnected Relay1 / SS2a Relay.1 / SS2a Relay.2)? The ENA Time Fuse-Links library identifier is in the model but the per-instance rating isn't queryable from the SQL columns.
- **System earthing:** What is the system earthing arrangement? The Utility rows have ZeroR / ZeroX populated but GroundingType / GroundingAmp are unset and there is no NER element. The L-G fault current used in §4 ($kAsc1p = 2.45$ kA at Max FL) is the directly-stated value; if the WPD source has an NER on the ground, the analytical I_{EF} will be lower.
- **Cable data integrity:** The SS4 Cable carries anomalous impedance values ($R = 211$, $X = 112$) inconsistent with the rest of the cable family. Confirm the intended cable type and re-enter the R/X values from the library reference — see Finding 5.8.
- **Load placement:** Are the ten loads genuinely all on bus SS1 LV1, or is the load aggregation a simplification? The audit takes Tx ratings as the FLC reference rather than feeder load.