

LT Unbalanced Precision Load Flow

Product Guide and Engineering User Manual

Survey to simulation to planning, one distribution transformer at a time

Chief Consultant Pakistan

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Survey. Analyse. Plan. Validate.

Welcome

Pakistan’s low-tension distribution system begins at the transformer secondary and ends at the individual consumer. It is where phase unbalance, voltage drop, conductor losses and rooftop solar interact in a network that is often recorded only in fragments. Chief Consultant’s LT Unbalanced Precision Load Flow brings field survey, phase-specific simulation and proposal analysis into one engineering workflow. Engineers can begin with one transformer, see the network down to its service connections and compare an intervention before putting it into the field.

This guide serves survey teams, distribution planners, operations engineers, DER reviewers and decision makers. It explains the engineering approach, the operator journey and the meaning of the results. All numerical examples illustrate particular network scenarios; users should run their own surveyed model for a decision concerning a specific transformer.

Engineering note

Product principle: complete visibility below the distribution transformer, with enough control for an engineer and a direct path from data capture to action.

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The workflow at a glance

Survey the assets with the LV Survey App; load the structured network into the web platform; select the loading strategy and visualization; run the baseline; investigate phase and section results; test a solar or planning proposal; and export an engineering record. Chapters 1–4 explain setup and baseline reporting, Chapters 5–7 cover solar impact, and Chapters 8–17 cover the Planning Suite and reports. The appendices collect the calculation framework and field quality checks.

Why Chief Consultant built it

At 400/230 V, network decisions are often made from transformer loading and customer complaints while the electrical condition of individual LT spans and service connections remains difficult to inspect. Traditional FDRANA-era workflows have often emphasized balanced, non-GIS LT analysis; modern utilities need a direct route from a field asset record to unbalanced and geographically grounded studies. A schematic-only study may miss the surveyed location of assets; a single balanced result can hide unequal phase currents; an aggregate solar adjustment cannot show which pole, service or phase is affected. LT-LoadFlow connects the field record to a phase-specific electrical model and makes each proposed change a repeatable engineering scenario.

Product capabilities

Capability	What the engineer can do
LV Survey App	Capture transformer, poles, sections, conductors, services, consumers and PV connection points with network and location data.
Analysis configuration	Import CSV/XLSX; choose upstream loading or measured R/Y/B currents; include power factor; select schematic or GPS view.
Unbalanced simulation	Solve phase-specific voltages, currents, power and losses using an OpenDSS-compatible model.
Technical reporting	Download the analysis report, section-level XLSX and DSS model script.
DER scenarios	Compare existing PV with its removal and test a proposed PV connection at a specific node and service.
Planning Suite	Stage relocation, capacity upgrade, a new transformer, reconductoring, phase configuration, new load, isolation or extension, then solve the modified network.
Comparison	Review baseline, growth and proposed cases and export the modified-grid and comparative workbooks.

Who uses the result

The surveyor creates the asset record; the operations engineer checks measured conditions; the planning engineer tests reinforcement; the DER engineer reviews an applicant or the cumulative PV fleet; and the approving engineer uses the exported model and reports to document a decision. This shared workflow keeps the study attached to a physical transformer and its actual downstream network.

Chapter 1

Why LT precision matters and how to survey the network

Purpose. Build a trustworthy electrical model from a field survey of one distribution transformer and its LT network.

Conventional LT planning often starts with an incomplete single-line diagram and an aggregate transformer load. LT-LoadFlow starts with the actual asset chain: transformer secondary, outgoing conductors, poles, service drops, consumer meters and DER points. It supports schematic and geographic presentation, balanced or phase-specific unbalanced studies, and OpenDSS-based analysis for the 400/230 V, 50 Hz distribution system. The engineer works with one transformer at a time, then tests proposed changes in the same modeled network.

1.1 Study boundary and asset chain

The analysis begins at the distribution transformer and follows outgoing LT line sections through poles and service cable to the consumer meter/DER connection. A study of one transformer and its associated secondary network is the basic operator unit. A planning action may split the network and introduce a second transformer (Chapter 11).

Transformer → LT main/branch → pole/node → service drop → meter/load/PV

A surveyed record needs stable node and section identities, connectivity, conductor type, length, phase designation, consumer quantity or demand, and the service connection characteristics. GPS coordinates enable geographic presentation, but geographic proximity alone never establishes electrical connection. Phase sequence, physical direction and conductor identity should be verified in the field.

1.2 Mobile survey interface

The LV Survey App records FromNode, conductor, phases, one-phase and three-phase connection quantities, associated loads and average service lengths. The field team identifies the transformer root, walks each outgoing line, preserves parent–child connectivity and records branches, consumers and DER sites. The form displays GPS accuracy and span information. Review routed lengths against physical spans before export, especially where a road or building requires a detour between mapped points.

Operator procedure. Select the existing FromNode; assign the downstream node and conductor; select the installed phases; enter consumer counts, demand fields and service lengths; save the section; repeat for every branch and service. Export the APK’s structured CSV/XLSX or use a supported live sync only after checking connectivity.

Verification. Check node names are unique; every non-root node has the intended upstream path; no section is duplicated; units are metres, kW/kVA and amperes as labelled; PV sites and phase connections match the field register. A disconnected or wrongly phased segment makes all later losses and voltages suspect.

1.3 Web access and authorship

Enter the authorization passcode and select *Unlock System*. The login page identifies Engr. Muza-mmil Adeeb as Chief Software Developer. Use an organization-issued account or passcode and follow the utility's data-handling policy for consumer and asset records.

5:39

4G+

VoLTE

52%

Survey

Edit Node

LV Survey

Accuracy: 4m

From: Node0 → To: Node1

Span: 0.8 m

FromNode

Node0

Cond

WASP

Phases

3-Phase

1-Phase Connection

Qty

0

Load

0

Avg Len

0

3-Phase Connection

3P Cable

19/0.052

Qty

0

Load

0

Avg Len

Figure 1.1: Chief Consultant LV Survey APK: section and connection capture.

CHIEF CONSULTANT
PAKISTAN

Unbalanced LT Analysis
Pakistan's First Precision Unbalanced LT Analysis & Proposal Engine

Authorization Passcode

Enter secure passcode

UNLOCK SYSTEM

Developed by:
Engr. Muzammil Adeeb
Chief Software Developer

Figure 1.2: Web authorization screen and developer attribution.

Chapter 2

Configure and run the first analysis

Purpose. Turn the surveyed network into a calibrated operating case with a few clear settings.

The dashboard accepts CSV or XLSX in the illustrated Chief Consultant APK format. Import is an ingestion step, not proof that a network is electrically sound. Keep the original survey export, date, transformer identifier and selected run settings together as a study record.

2.1 Choose the allocation strategy

Choice	Operator input	Appropriate use and check
Strategy 1: Upstream kVA loading	Transformer target loading percent; where available upstream-derived kVA and power factor	Use when a compatible upstream study provides the loading target. Confirm rated transformer kVA, percent base, load timestamp and whether upstream results already include downstream PV.
Strategy 2: LV clamp meter	Red, Yellow and Blue secondary currents in amperes; optional measured phase power factors	Use a synchronous field/AMI snapshot. Record time, secondary voltage, meter direction and instrument placement; one phase reading at a different hour is not a coherent snapshot.

When measured power factor is available, include it to refine the active and reactive power allocation. When it is unavailable, record the adopted study power-factor setting with the run, because current magnitude alone does not uniquely determine kW and kVar.

2.2 Figure type and run

Choose *Schematic (Topology)* to inspect connectivity independent of coordinates or *Geographic (GPS)* to inspect surveyed placement. A geographic map does not change the electrical graph; compare the two if a span seems misplaced. Press *Run Precision Analysis* only after reviewing the loaded file and settings. Capture the application version, input file checksum or revision, transformer rating, strategy, time and figure type in the study log.

Verification. Compare total consumer counts to the survey; inspect a long tail and a branch junction; confirm phase currents against measured inputs against the recorded field readings. Investigate material mismatches before using the model for investment or connection decisions.

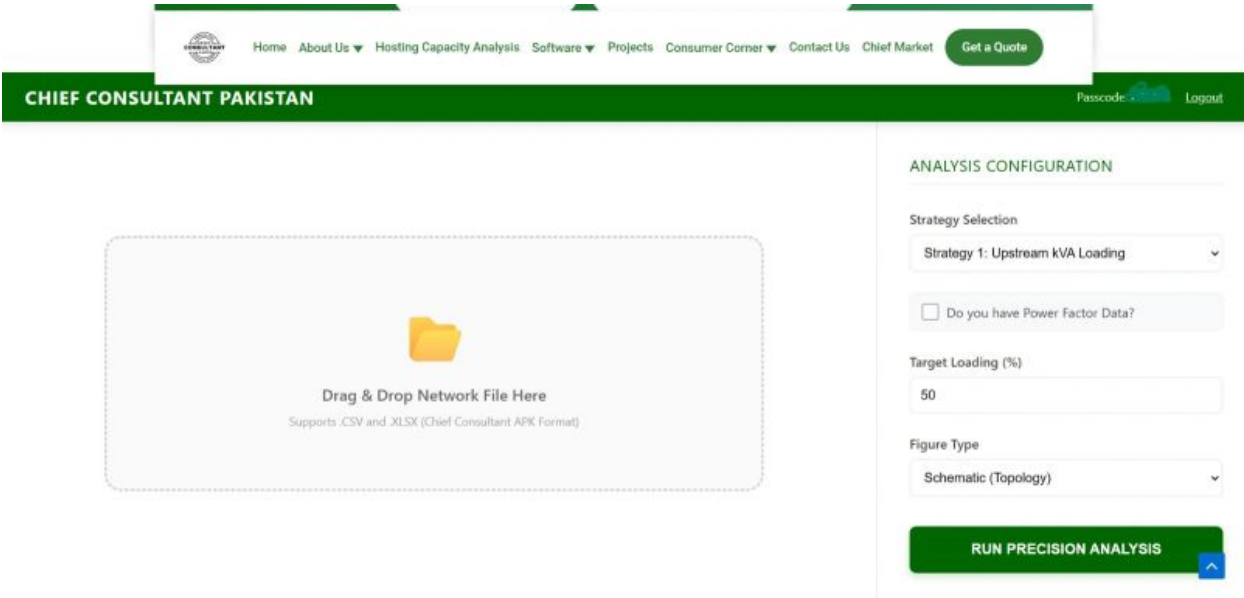


Figure 2.1: Upload and analysis configuration dashboard.

Chapter 3

Read the results dashboard

Purpose. See the electrical condition of the transformer network at a glance and inspect the phase detail beneath each KPI.

A representative results dashboard displays grid input 99.98 kVA, system efficiency 92.25%, total technical losses 3.604 kW, phase currents R 92.9 A, Y 182.2 A and B 166.0 A, and a live topology render. The asset panel shows 116 single-phase consumers, 7 three-phase consumers and 20 net-metering/PV connections. These values describe one modeled transformer network.

3.1 How to read the cards

Grid input is apparent power at the modeled upstream boundary. Technical losses are real power in kW. Never subtract the two directly without power factor and a consistent boundary. The phase currents are an immediate screen for unbalance: here Y is materially higher than R. A transformer may be within aggregate kVA while an individual phase or service is stressed.

Engineering note

Read each dashboard as a complete operating case. Grid input is in kVA, losses are in kW, and efficiency is a separate KPI calculated for its own defined boundary. Use the exported report for the detailed power and loss accounting behind a decision.

The central network view shows trunk, branches and connection points. Check for topology gaps and unusually concentrated voltage or loading indicators before exporting. *Analyze New File* begins a new study; save the present exports first.

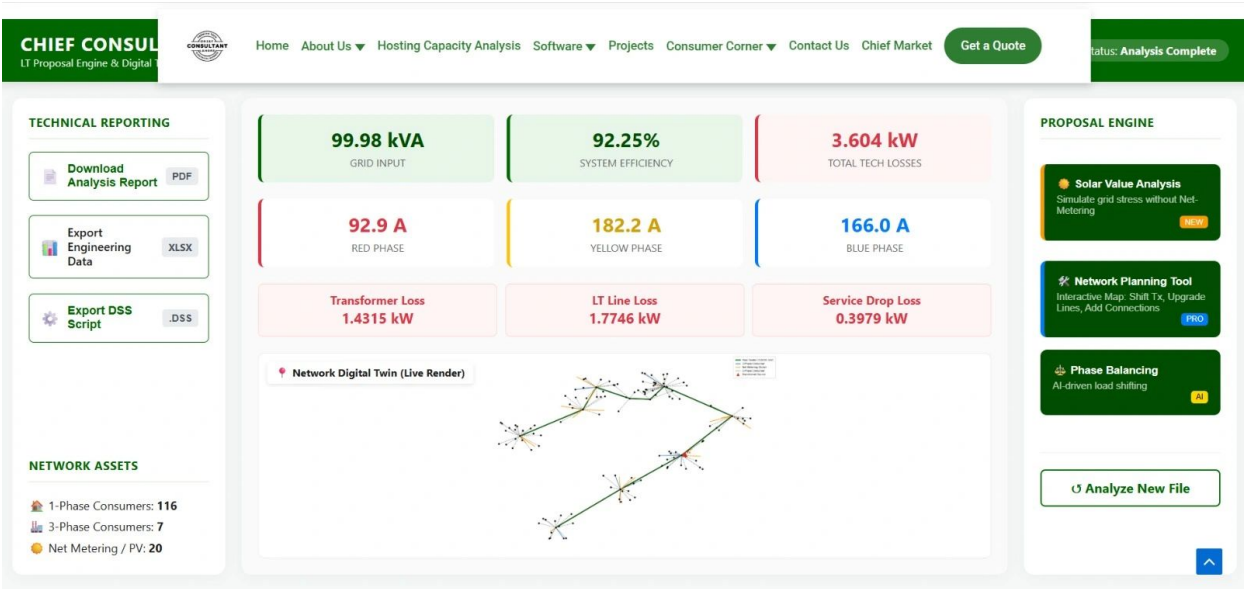


Figure 3.1: Baseline KPI cards, network digital twin, reporting and proposal entries.

Chapter 4

Trace performance to every line section

Purpose. Locate the conductors and phases responsible for loading, voltage drop and technical loss.

The *Export Engineering Data* control produces an XLSX section analysis. The export identifies SectionId, FromNode, ToNode, length, cable type, then per-phase voltage, current, power factor, real/reactive input, real/reactive loss and voltage drop. Sections use identifiers such as 123_4; preserve them when annotating field work orders.

4.1 Interpret a row

For the illustrated section 123_4, from Node1 to Node4, a roughly 55 m WASP span carries unequal phase currents; the example contains approximately 61.5 A on R and 124.3 A on Y, with Y voltage drop about 2.98 V and active loss about 0.269 kW. This supports a targeted review of loading, connection mapping and conductor suitability. Do not infer an overload without an applicable conductor ampacity and installation conditions.

$$P_{\text{loss,section}} \approx \sum_{\phi \in \{R,Y,B,N\}} |I_{\phi}|^2 R_{\phi} \quad (\text{simplified thermal relation}), \quad (4.1)$$

$$\Delta V_{\phi} \approx \text{Re}\{I_{\phi} Z_{\phi}\} \quad (\text{approximate per-phase drop}). \quad (4.2)$$

A full unbalanced solution includes coupling, neutral path and complex phasors as modeled; the relations above are for interpretation, not reconstruction of the exported solver result. Review sign conventions for reverse flow; negative section power may be legitimate at PV-rich times.

Operator procedure. Export XLSX, filter by worst voltage, phase current and real loss, then trace each flagged section on the map. Keep both the raw export and an annotated working copy. Export the DSS script when an independent OpenDSS review or archival replay is required.

Verification. Sum section and service losses only over the correct electrical boundary; avoid double counting. Compare section IDs and conductor names to survey records. Keep the original workbook as the auditable result of the run.

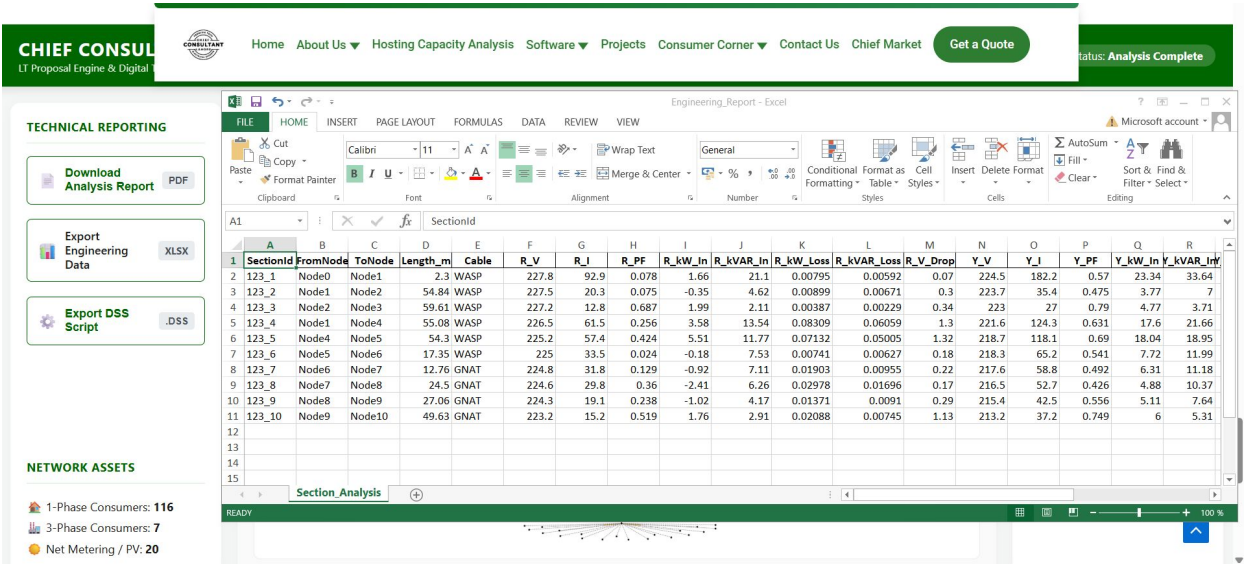


Figure 4.1: Engineering XLSX: section identifiers and per-phase result columns.

Chapter 5

Open the solar impact workspace

Purpose. Compare the present network with a matched case in which existing PV output is removed.

The *Solar Value Analysis* proposal entry opens a DER impact view. The operator starts with the already calibrated existing-PV baseline. The no-PV scenario removes modeled solar output while retaining an otherwise comparable network and demand snapshot; only under that controlled comparison can the change be attributed to the modeled PV.

5.1 Counterfactual contract

Write down the PV capacities and output factors or timestamps used, phase and service mapping, load allocation, transformer source voltage, topology and conductor data. Document the assumed behind-the-meter demand used for the comparison. *Removal of PV generation* is not the same as disconnection of the whole customer.

Operator procedure. From the baseline results, open Solar Value Analysis; run the existing-versus-no-solar comparison; confirm the two panels' scenario names and units; export or capture both outputs with their input assumptions.

Verification. Ensure no-PV input and losses respond in a physically plausible direction, while allowing local exceptions: a particular service may have higher current and loss with PV because reverse flow can increase its I^2R .

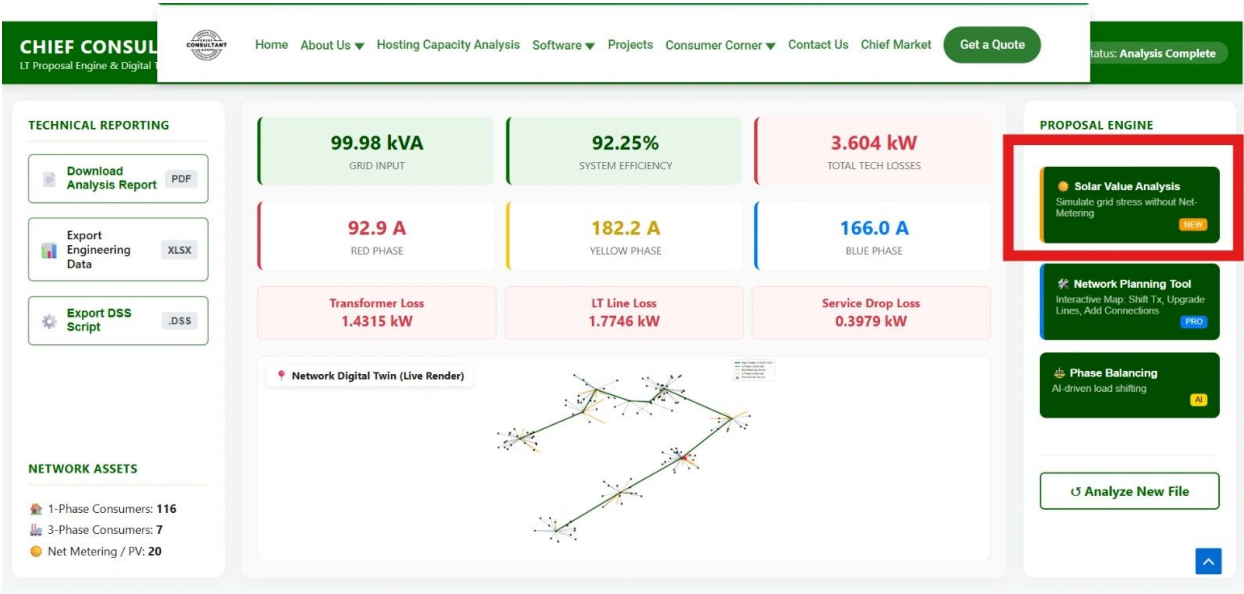


Figure 5.1: Proposal Engine entry for Solar Value Analysis.

Chapter 6

Measure the contribution of existing rooftop solar

Purpose. Measure the operating-point relief provided by the modeled rooftop solar fleet.

Figure 6.1 reports 99.98 kVA with PV and 174.16 kVA without PV: the modeled capacity difference is 74.18 kVA. Real technical losses rise from 3.3983 kW to 7.8626 kW, a 4.4643 kW difference. The line and transformer losses increase; the service component in this example decreases from about 0.1897 to 0.1254 kW. Phase currents rise from roughly (92.8,182.2,166.0) A to (181.6,294.5,276.2) A. Minimum voltage drops from 0.922 to 0.878 pu; maximum reported drop grows from 17.9 to 28.2 V.

$$\Delta S_{\text{input}} = 174.16 - 99.98 = 74.18 \text{ kVA}, \quad (6.1)$$

$$\Delta P_{\text{loss}} = 7.8626 - 3.3983 = 4.4643 \text{ kW}, \quad (6.2)$$

$$\frac{\Delta P_{\text{loss}}}{P_{\text{loss,with PV}}} \approx 131.4\%. \quad (6.3)$$

The last percentage expresses the extra loss in the no-solar case relative to the with-solar loss. With the no-solar case as denominator, PV reduces modeled losses by about 56.8%. State the denominator in every report. Convert snapshot kW effects to annual kWh only with a representative time series.

Engineering note

This worked solar scenario is reported as its own pair of cases. Compare its PV-present and PV-removed columns with each other; take baseline settings and component definitions from the corresponding exported impact report.

Engineering interpretation. The scenario supports an operating-point estimate of how the modeled PV changes transformer input, phase currents, voltage and modeled losses. Generalization to annual avoided energy, tariffs or policy outcomes requires time-series operating data and validated PV output.

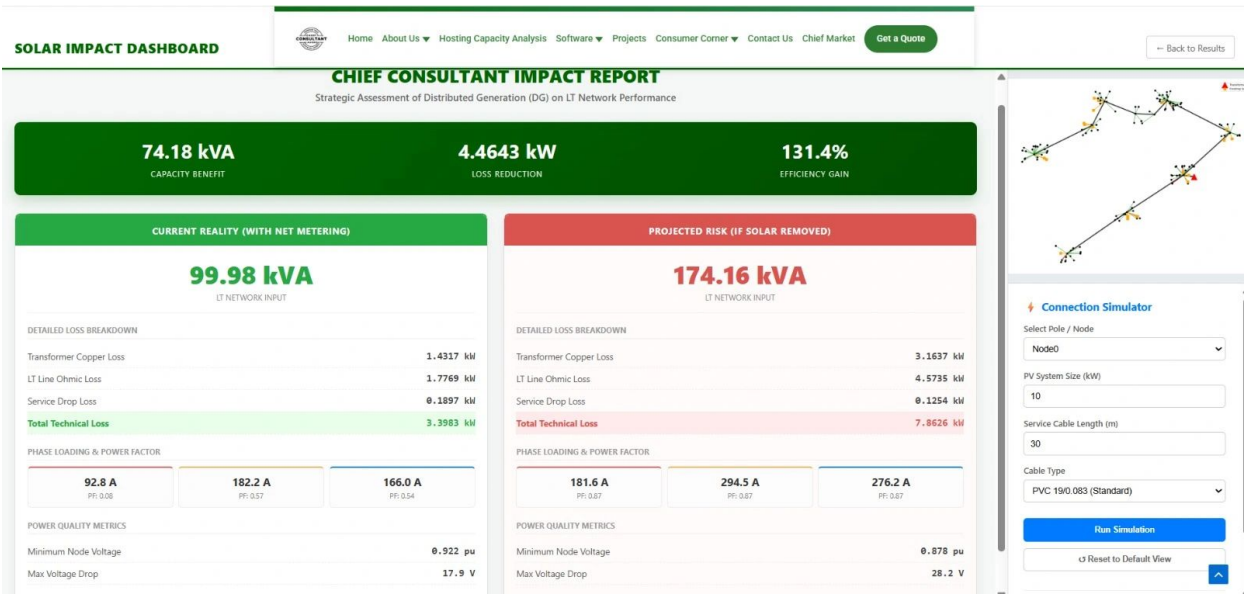


Figure 6.1: PV-present versus PV-removed impact report.

Chapter 7

Study a proposed PV connection

Purpose. Test a proposed PV connection on the actual LT path to its meter.

The Connection Simulator example selects Node0, enters a 10 kW PV system, 30 m service length and PVC 19/0.083 cable. The pictured baseline is 99.98 kVA input and 3.3983 kW loss. After the proposed connection it displays 90.92 kVA and 3.0044 kW; thus the indicated differences are 9.06 kVA and 0.3939 kW. The service component increases from about 0.1897 to 0.2179 kW while other categories decrease. The minimum voltage improves from 0.922 to 0.932 pu and maximum drop falls from 17.9 to 15.8 V.

Operator procedure. Choose the physical pole/node; confirm whether the connection is single-phase or three-phase and its R/Y/B assignment; enter proposed PV rating, inverter operating assumption if available, service cable type and measured route length; run and compare with the unchanged baseline. Repeat at relevant minimum-load/high-PV and peak-load/low-PV conditions before making an interconnection decision.

Verification. Inspect maximum as well as minimum node voltage, reverse power, phase/neutral currents and equipment ratings. Repeat the assessment at the relevant low-load/high-generation and peak-demand operating points before an approval recommendation.

Engineering note

The 10 kW system rating is a real-power nameplate; 9.06 kVA is the modeled change in apparent power at the grid boundary. The two values need not be numerically equal. Review inverter output, power factor and losses when explaining the marginal effect of a connection.

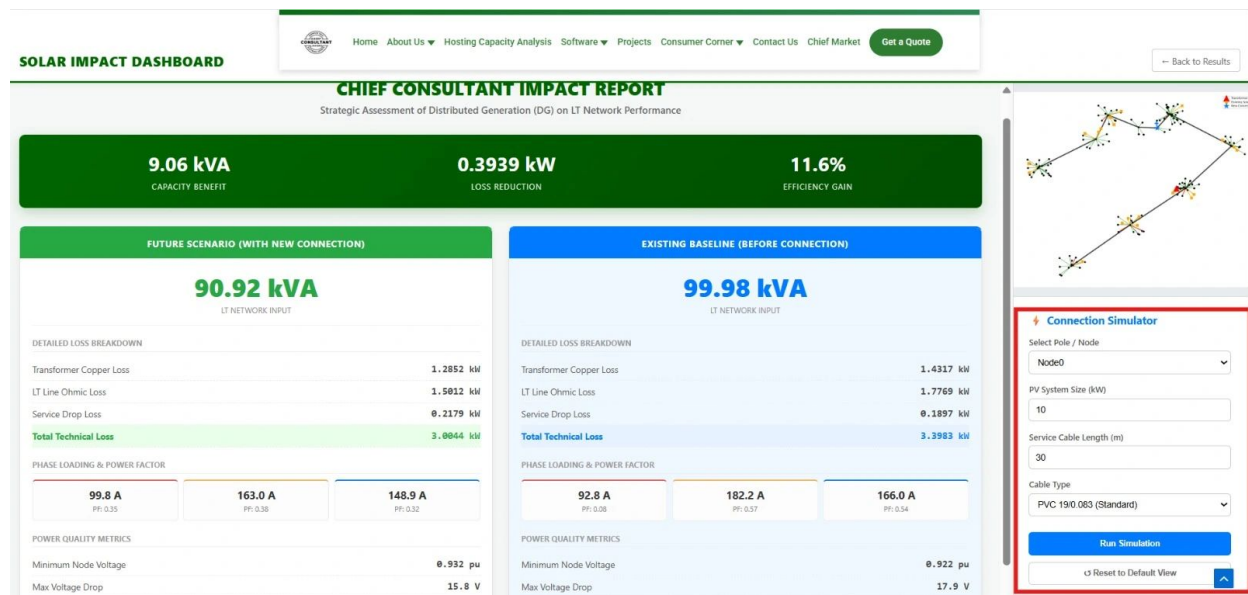


Figure 7.1: New PV connection input and before/after dashboard.

Chapter 8

Enter the interactive Planning Suite

Purpose. Stage engineering changes on an interactive network and solve the proposed condition.

The Planning Suite opens through *Network Planning Tool*. The Modification Toolkit lists Transformer Optimization, Add New Transformer, Reconductoring, Phase Balancing, Add Connections, Disconnect Node and Network Extension. The screen has a map, current analysis results and an Execution Stack. Proposed actions are staged in that stack, then evaluated by *Run Simulation*; the engineer runs the simulation to see the electrical result.

8.1 Phase configuration study

The Phase Balancing section can be used to select a network section and stage a phase configuration change, such as re-phasing the chosen section to RYB. Run the modified network and compare R/Y/B currents, losses and voltage. A useful field proposal also records the customers affected, the required conductor and neutral work, and the switching plan. The interface presents this planning control alongside the other modification tools.

8.2 Working discipline

Start from a named, exported base case. Add one action to isolate its effect, run, record results, and only then combine actions if the causal interpretation is clear. When a new transformer splits the network, compare every resulting supply zone and the combined boundary rather than selecting one attractive panel. The planning view shows approximately 99.96 kVA, 3.6029 kW loss and 0.92 pu worst-node voltage for its example base. Use the Planning Suite baseline displayed alongside its own proposed scenarios.

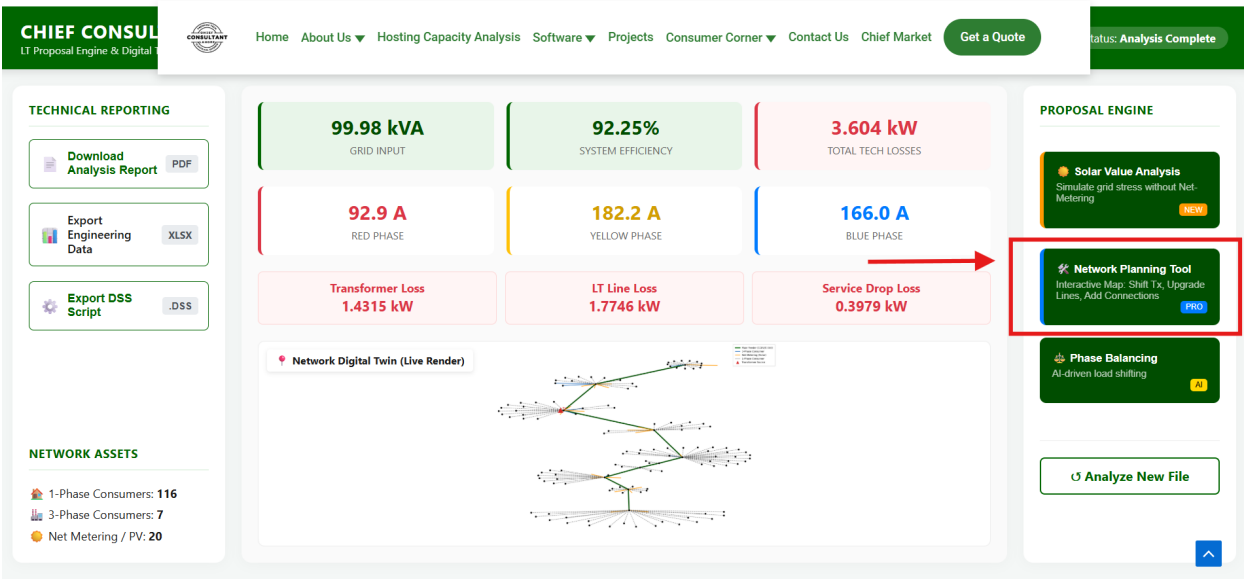


Figure 8.1: Results dashboard link to the Network Planning Tool.

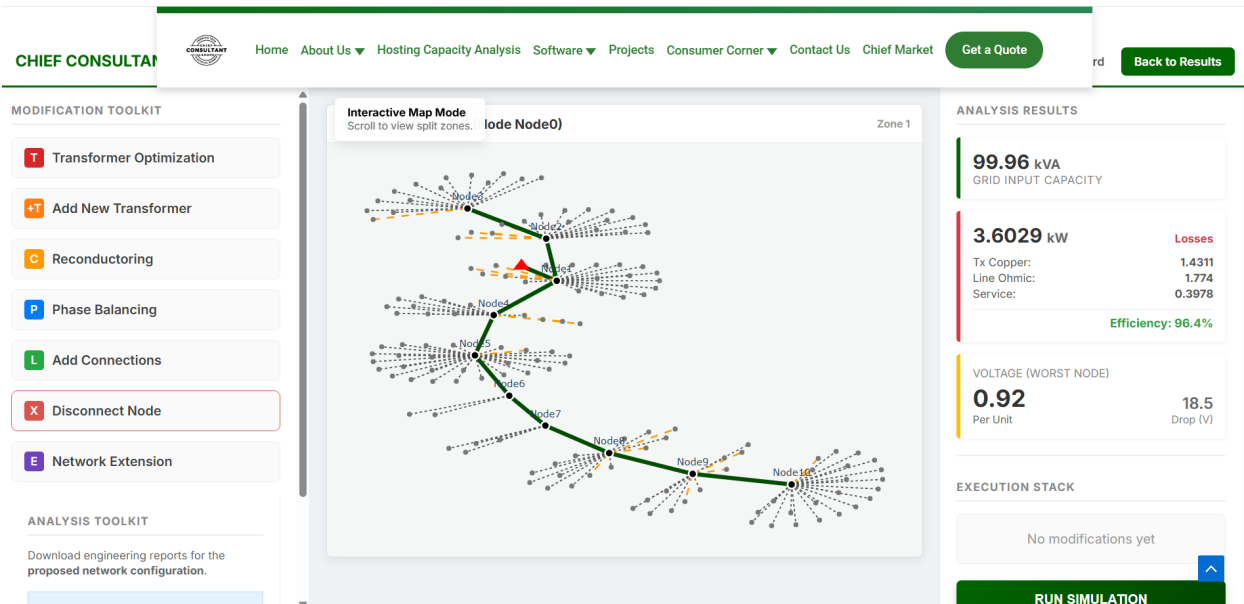


Figure 8.2: Planning Suite layout, Modification Toolkit and Execution Stack.

Chapter 9

Optimize transformer location

Purpose. Compare source locations to reduce long high-current paths and improve service voltage.

Figure 9.1 stages *Shift Source To Node5*. Figure 9.2 shows a relocated source icon and reported losses falling from 3.6029 to 2.8747 kW; the worst-node voltage rises from 0.920 to 0.944 pu, and the displayed efficiency rises from 96.4% to 97.13%. This example suggests relocation improves this modeled topology, not that Node5 is generally optimal.

Operator procedure. Choose a feasible existing node; stage *Shift Transformer*; run; note total and section losses, worst and highest voltages, R/Y/B loading, and service implications. Screen candidate sites for land, 11 kV access, construction and protection constraints before treating an electrical optimum as a buildable plan.

Engineering interpretation. Relocation changes the lengths over which aggregate branch currents flow. Since conductor loss scales roughly with current squared, shortening heavily loaded upstream paths can outweigh modest added distance elsewhere. The effect is topology and load-specific.

Verification. Check that transformer rating and demand were held fixed and no consumers were dropped or reconnected incorrectly. Evaluate more than one loading snapshot before investment.

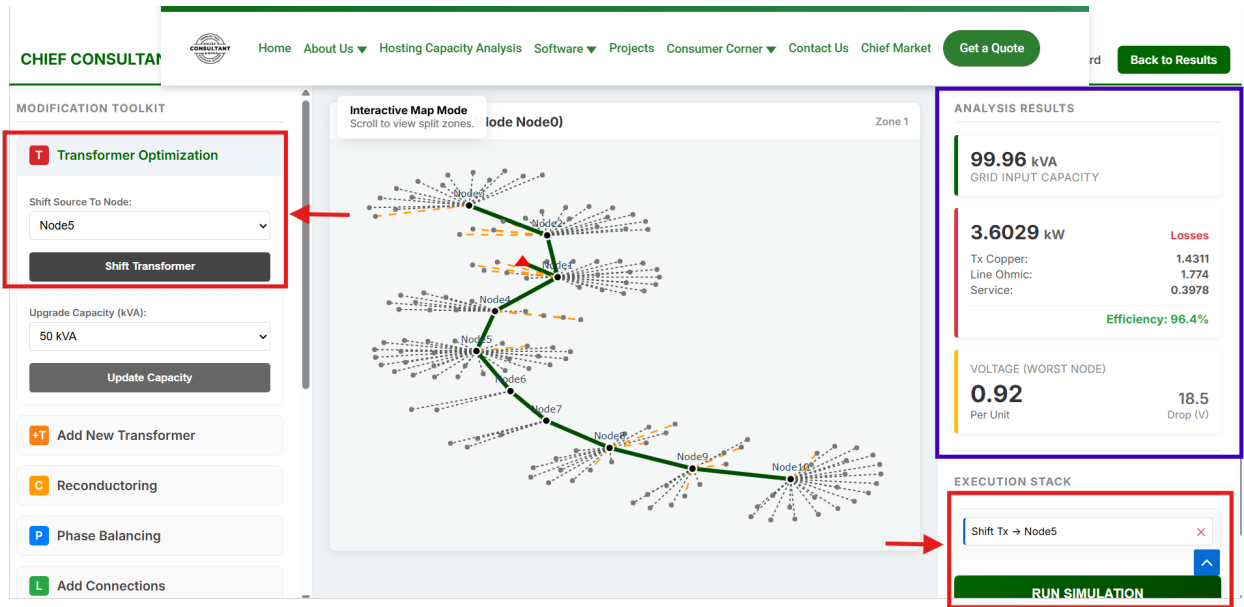


Figure 9.1: Staging transformer source relocation to Node5.

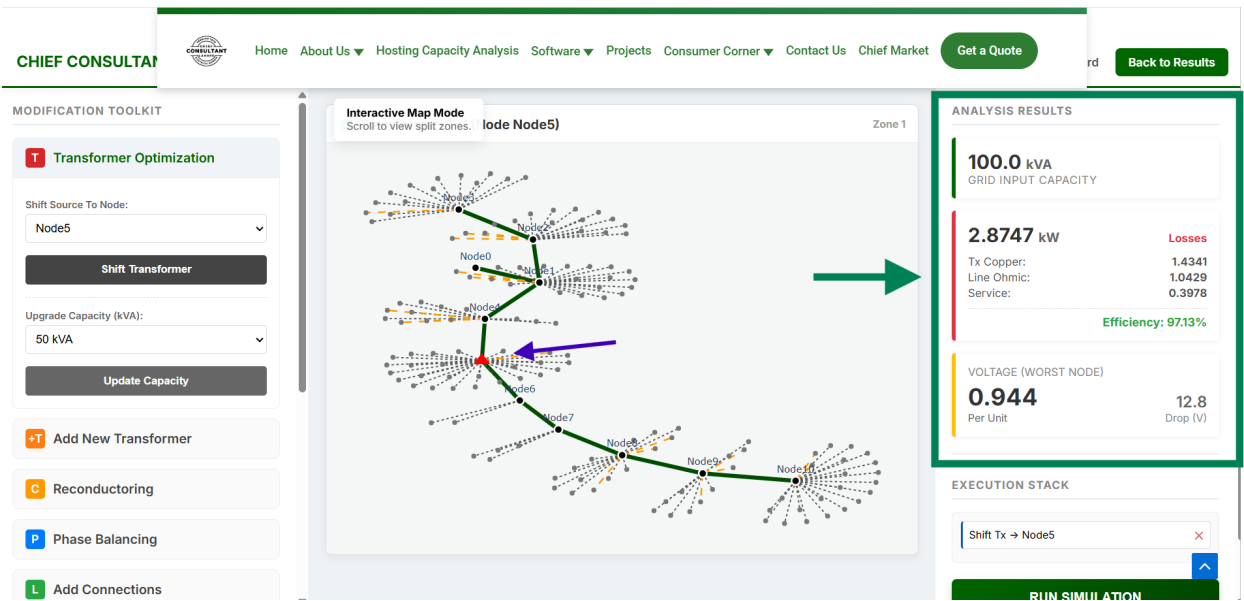


Figure 9.2: Solved relocation example and KPI changes.

Chapter 10

Upgrade transformer capacity

Purpose. Test whether a larger transformer resolves the actual network constraint.

The capacity selector changes the transformer to 400 kVA. The example shows total loss decreasing from 3.6029 to 3.4623 kW and worst-node voltage rising from 0.920 to 0.934 pu. The line and service network remains in place, so voltage recovery can be partial. The change reflects the selected transformer electrical parameters and the loading snapshot.

Operator procedure. Select the proposed kVA from the available list, stage *Update Capacity*, run and check transformer loading, source voltage, copper/no-load losses, downstream phase currents, minimum voltage and persistent high-loss spans. Compare with relocation and reconductoring on the same baseline.

Verification. Confirm that new impedance and no-load parameters correspond to the proposed unit; a pure nameplate edit without matching electrical parameters would invalidate the interpretation. Record the proposed transformer technical data in the design file.

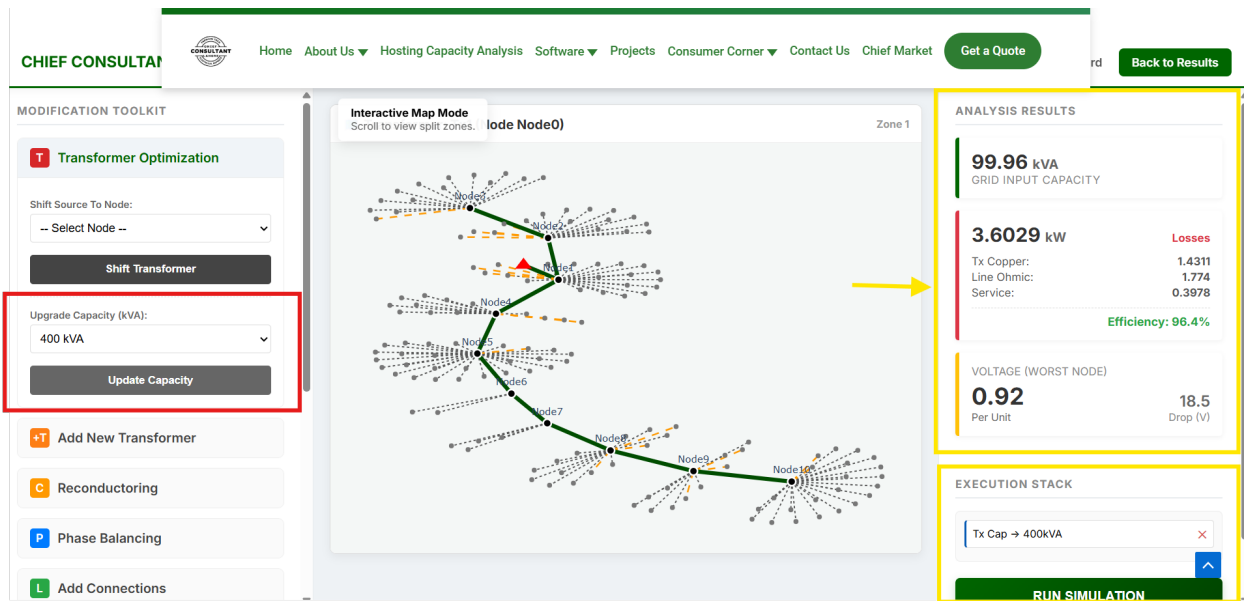


Figure 10.1: Proposed transformer upgrade to 400 kVA.

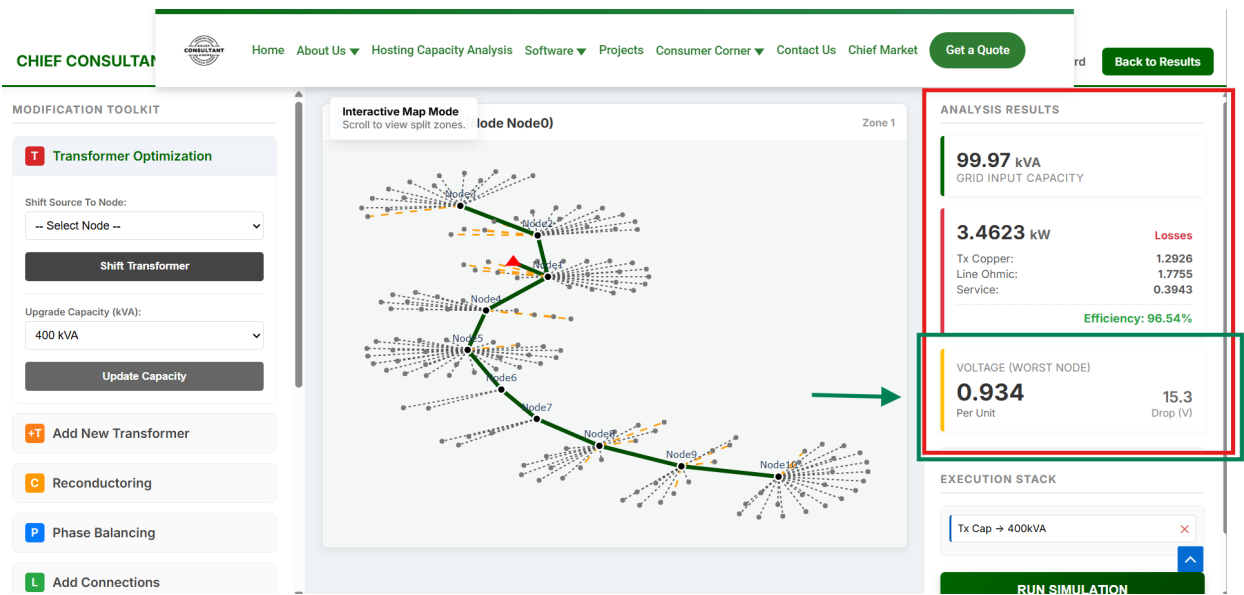


Figure 10.2: Upgrade result: partial voltage improvement and reduced loss.

Chapter 11

Install a second transformer and split the load

Purpose. Split a network into two modeled transformer zones and compare their performance.

The form disconnects the network at a selected node, inserts a transformer source at another node, specifies rating (100 kVA in the example) and a growth factor (1.27). The resulting display has two transformer zones. The example reports Tx1 49.42 kVA input and 1.0732 kW losses, while Tx2 reports 77.54 kVA and 4.4929 kW losses. A strong Tx1 result does not erase the weak Tx2 zone: its worst-node voltage is shown around 0.900 pu and its loss remains high.

Operator procedure. Select the cut node and new transformer node using the topology; specify capacity and the demand growth multiplier deliberately; stage the action and run; inspect both resulting zones and aggregate assets. Export the comparison and modified grid, then examine source siting, 11 kV supply and protection arrangements outside the LT load-flow result.

Engineering note

A growth factor of 1.27 represents a 27% increase in the demand to which it is applied. Keep the same demand assumption across alternatives or show both the growth-only stress case and the growth-plus-investment case.

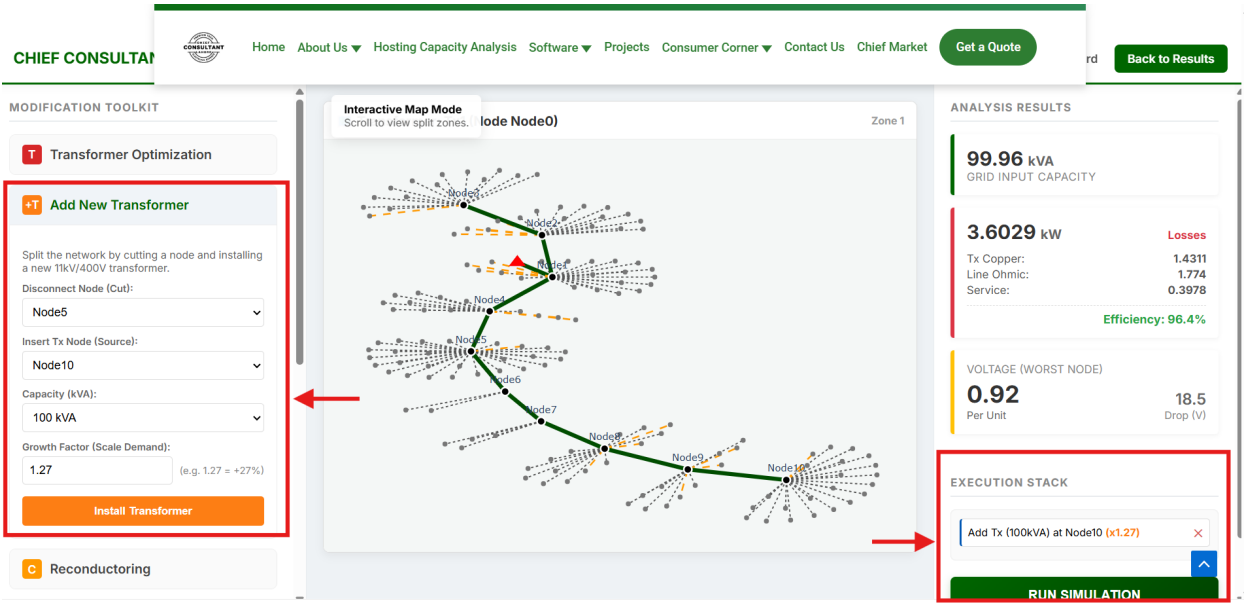


Figure 11.1: New-transformer cut, source, capacity and growth inputs.

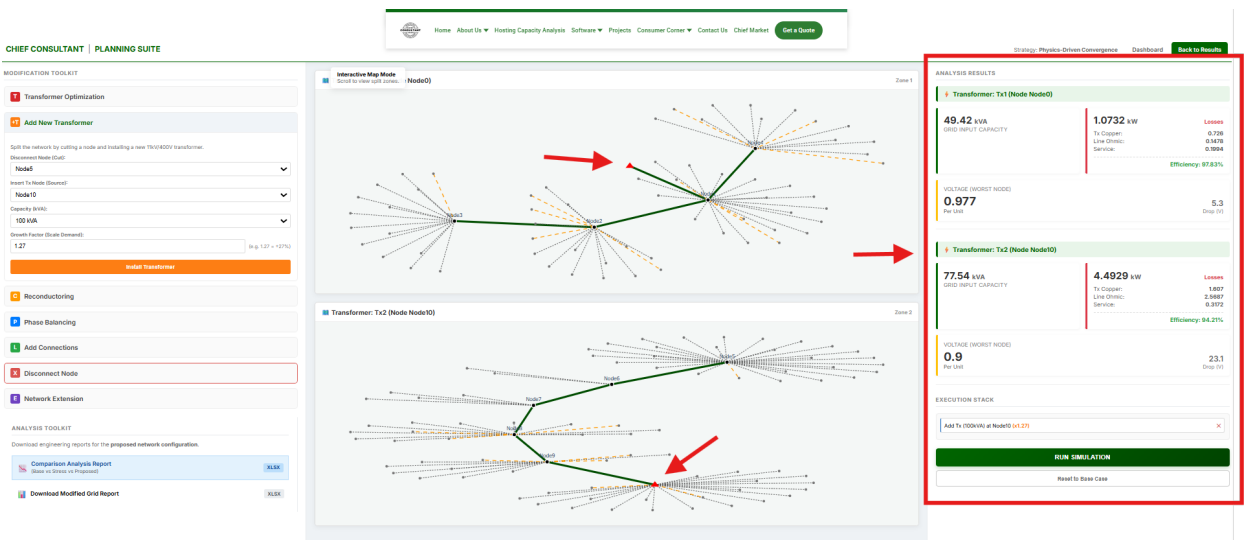


Figure 11.2: Two-zone proposal, separate transformer result panels.

Chapter 12

Reconductoring and section reinforcement

Purpose. Target the span where a conductor upgrade gives measurable electrical benefit.

To study an upgrade, the operator clicks a line to select section 123_10, chooses a replacement conductor (PVC 19/0.083 in the illustrated selector) and stages *Upgrade Conductor*. The reported total loss changes from 3.6029 to 3.4818 kW and worst-node voltage from 0.920 to 0.926 pu. The result is conditional on the actual conductor resistance, reactance, ampacity, installation type and length.

Operator procedure. Use the section export to rank candidates by loss, drop and thermal stress; select the matching map edge; verify its endpoints and installed type; choose a physically suitable replacement; run and compare per-phase section results.

Verification. A candidate cable should be assessed for current rating, neutral sizing, short-circuit withstand, environment, standards and construction feasibility. A lower R does not alone prove a proper overhead replacement. Select the replacement conductor using the utility-approved material and construction standard.

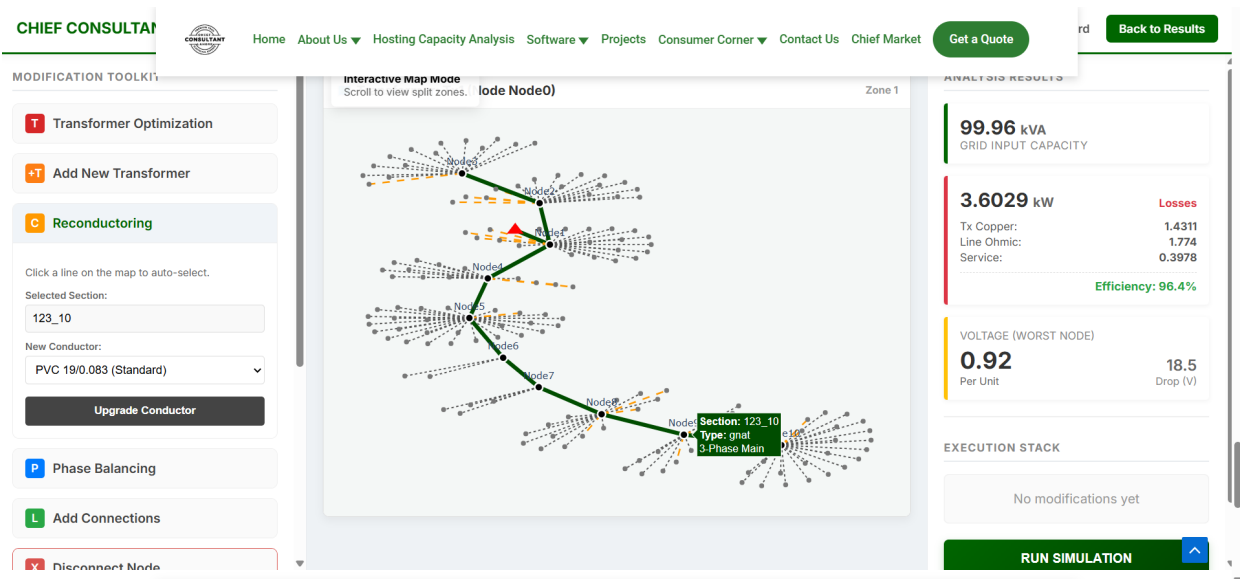


Figure 12.1: Selecting a line section and replacement conductor.

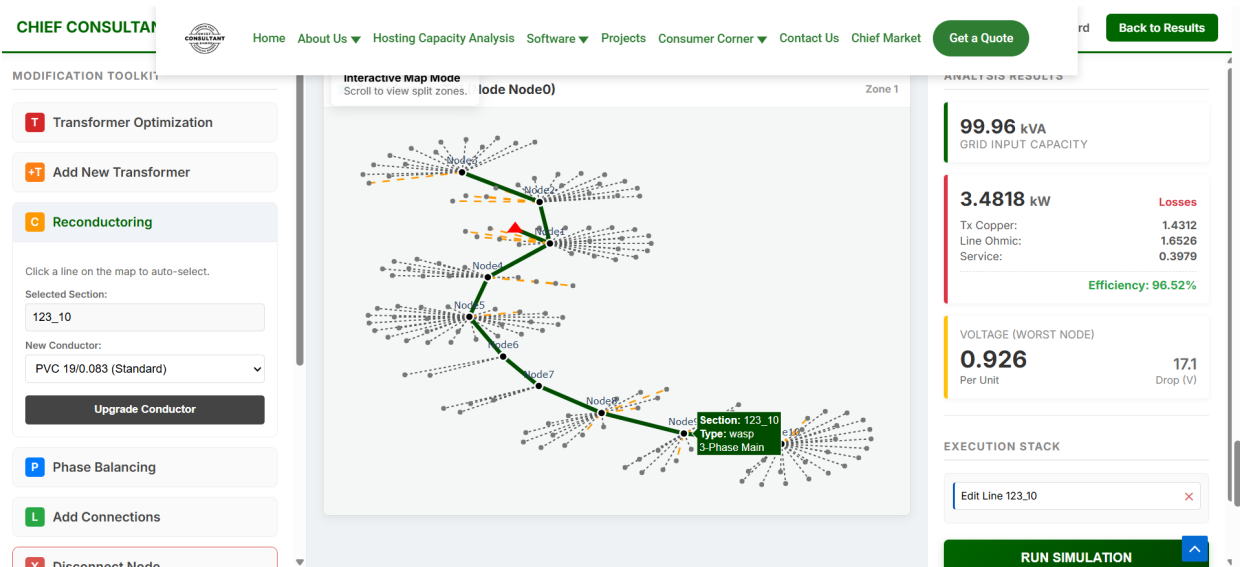


Figure 12.2: Solved reconductoring scenario.

Chapter 13

Evaluate a new consumer connection

Purpose. Check the electrical effect of a proposed consumer before connection.

The example adds a 2 kW connection at Node7 with a selected consumer type, PVC 7/0.052 service and 20 m length. The screen after solving reports input 102.17 kVA versus 99.96 kVA, loss 3.7258 versus 3.6029 kW, and worst-node voltage 0.918 versus 0.920 pu. These are apparent-input and real-loss comparisons at a modeled snapshot; a 2 kW load need not raise kVA input by exactly 2.

Operator procedure. Click the intended pole; set consumer category, phase(s), load kW and power factor where the form provides it; enter service cable and route length; stage *Inject Load*; run and inspect the targeted phase, service and upstream path.

Verification. Check the service type matches sanctioned supply, transformer capacity alone is not the only gate, and both peak and representative operating points meet voltage/thermal criteria. Record the selected consumer class and phase arrangement with the application.

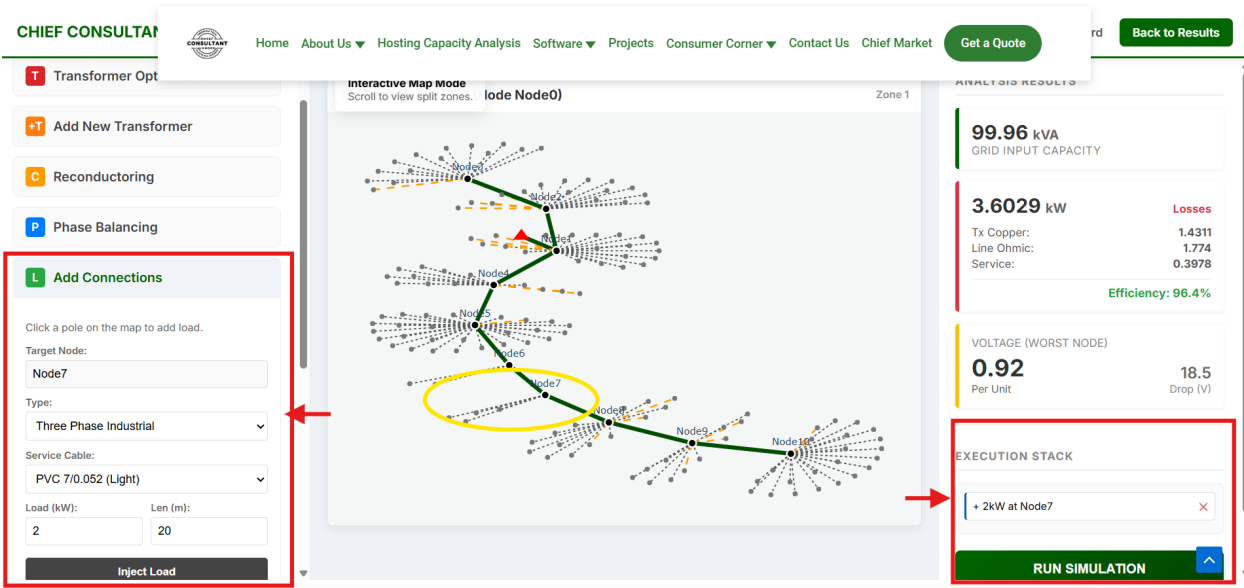


Figure 13.1: Adding a proposed connection at Node7.

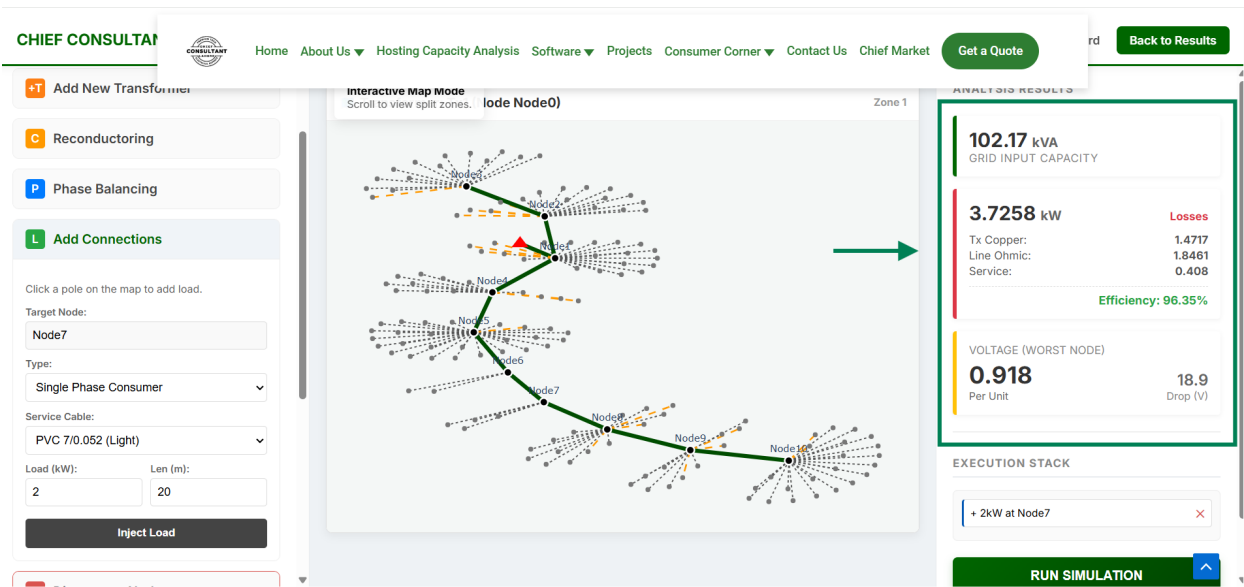


Figure 13.2: Solved 2 kW addition and changed KPIs.

Chapter 14

Study disconnection and isolation

Purpose. See the electrical and customer-service consequences of isolating a node.

The toolkit says *Click a node to isolate it and all downstream loads*. The example stages *Cut Power at Node7*. The resulting input falls from about 99.96 to 75.06 kVA, losses from 3.6029 to 1.8044 kW, and worst-node voltage rises to 0.962 pu. The electrical change accompanies a loss of service to the isolated downstream customers; report both effects.

Operator procedure. Identify the target node and all downstream customers before staging; run; verify the disconnected tree and whether alternate feeds exist; record unserved demand, consumers and critical loads alongside the electrical output.

Engineering interpretation. Use this scenario for isolation, reconfiguration screening and restoration planning. For a credible outage decision, report unserved energy over duration, affected customers and safety constraints; include the duration and affected customer count when evaluating an operational outage plan.

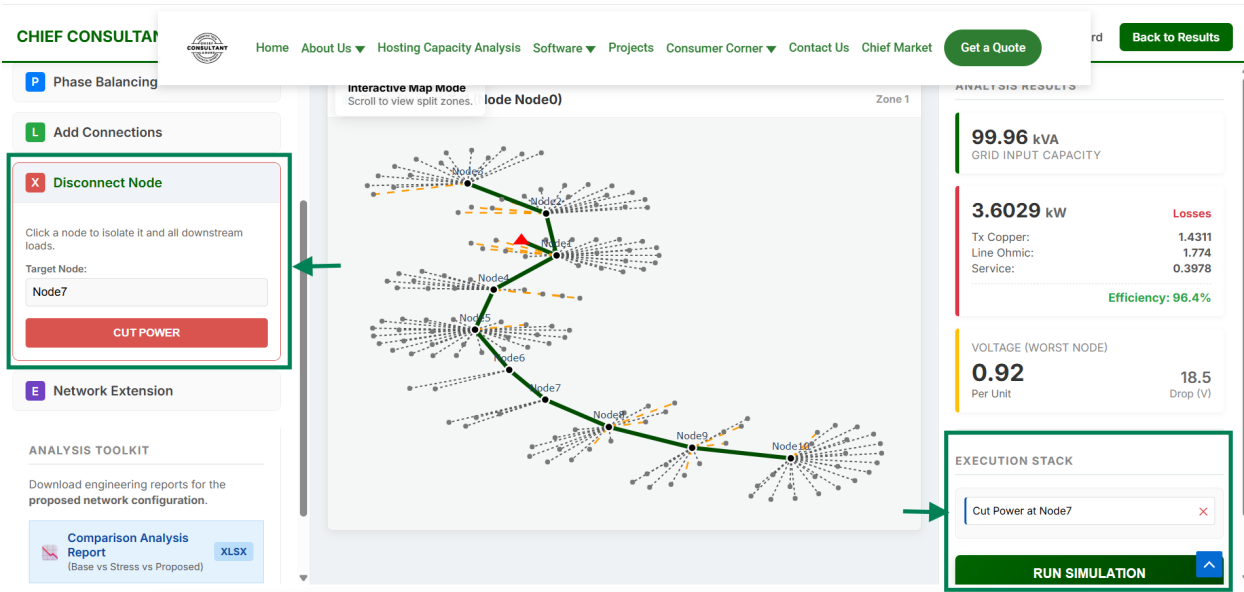


Figure 14.1: Disconnect Node selection and staged cut at Node7.

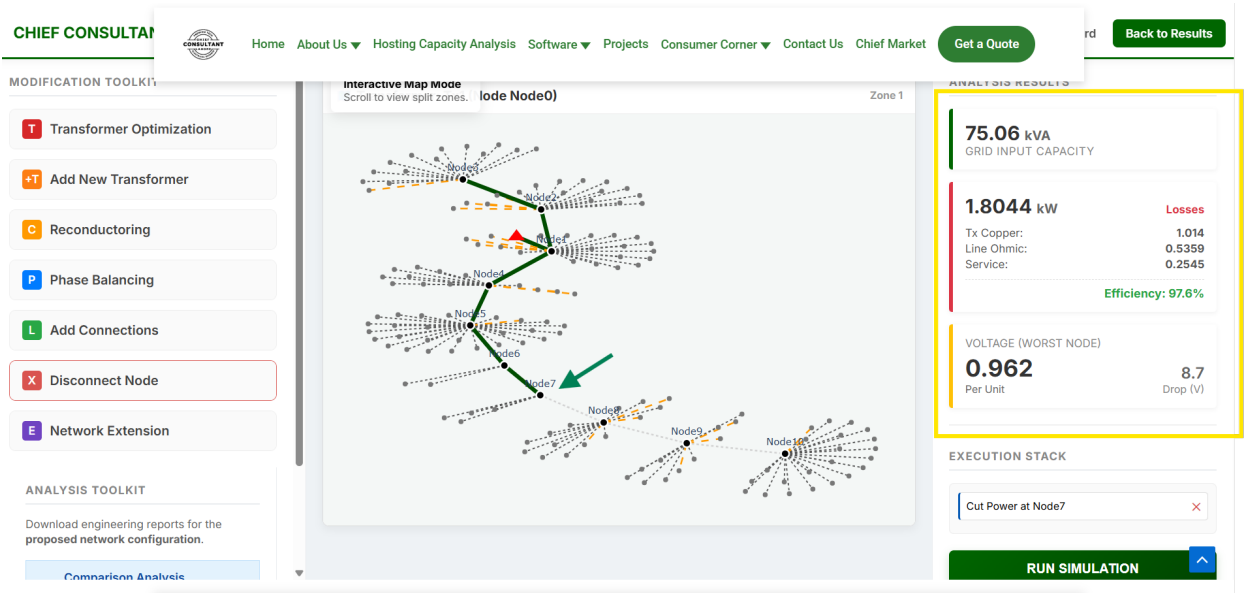


Figure 14.2: Result after removing downstream service.

Chapter 15

Design an LT network extension

Purpose. Build an extension and then evaluate the loads or DERs it will serve.

The extension form shows a parent Node8, new node Node_8A/8A, length 40 m, 2-phase RY and ACSR Ant (50 mm) example type. The extension is visualized near Node8. With no attached load in this example, the result cards remain at 99.96 kVA, 3.6029 kW and 0.920 pu. Add the intended customers or DERs to quantify the loaded extension.

Operator procedure. Choose the correct parent, unique new node name, installed phase set, routed length and conductor; stage *Build Extension*; run; then add intended consumers or DERs as a separate action and rerun to measure the actual loaded impact.

Verification. Verify route feasibility, clearances, neutral provision and whether the phase set can serve the proposed connections. An empty extension is principally a topology change in a steady-state load-flow study.

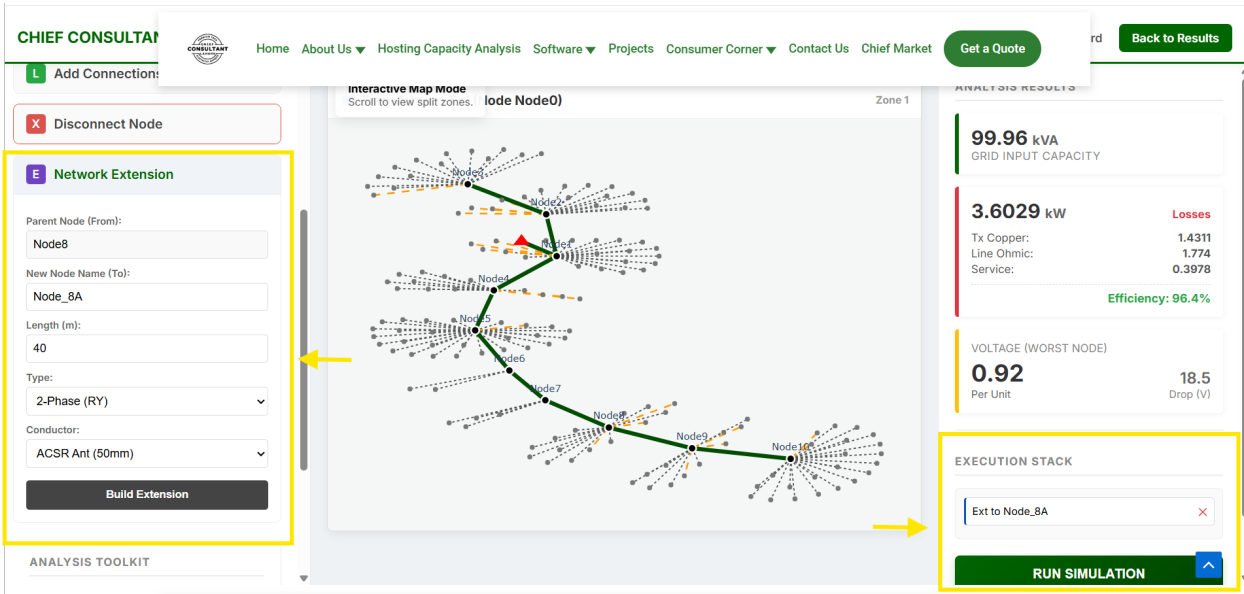


Figure 15.1: Network extension input and queued action.

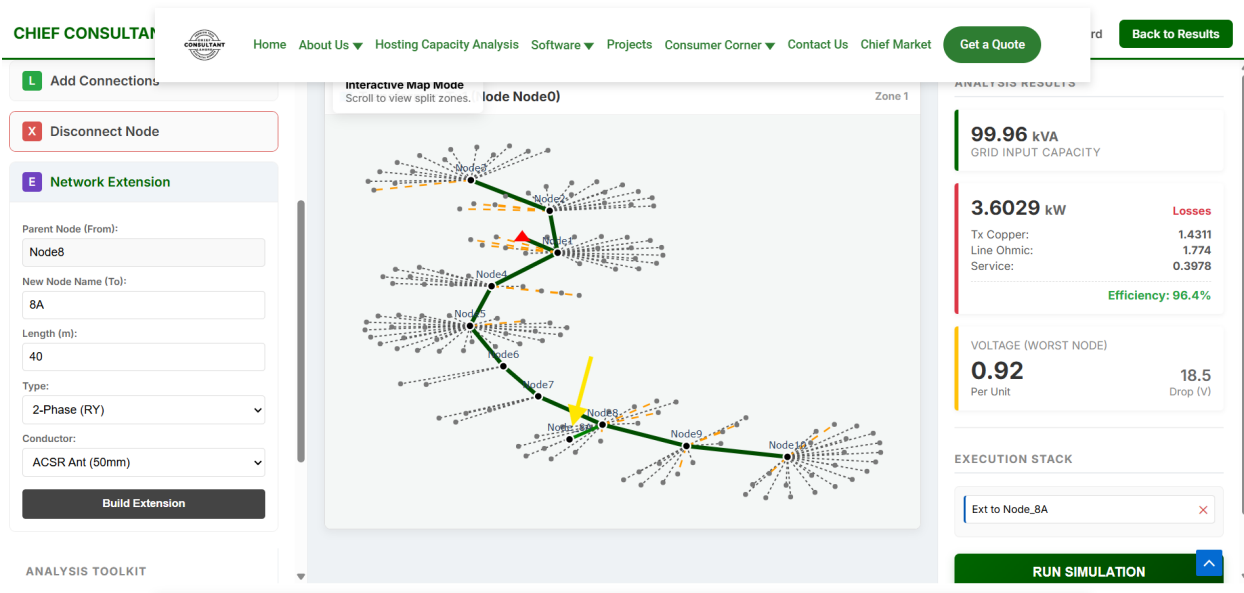


Figure 15.2: Visualized new extension near Node8.

Chapter 16

Export the modified network

Purpose. Export the solved proposed network for engineering review.

The Planning Suite includes *Download Modified Grid Report* as XLSX. Figure 16.2 shows section-level phase columns. Export after a solved proposal, and retain both the original base export and the modified export. Use section IDs and From/To nodes to match spans; added or cut nodes require a mapping rather than blind row-by-row subtraction.

Operator procedure. Record the complete Execution Stack, run simulation, download the modified grid and the comparison report, then name the files with transformer ID, date, scenario and version. Compare worst nodes, loss contribution and current for all phases, not just the KPI summary.

Verification. Check for negative flow sign, changed section order, phase-specific blank cells and revised topology. Use the workbook headings as the column definitions for the exported release.

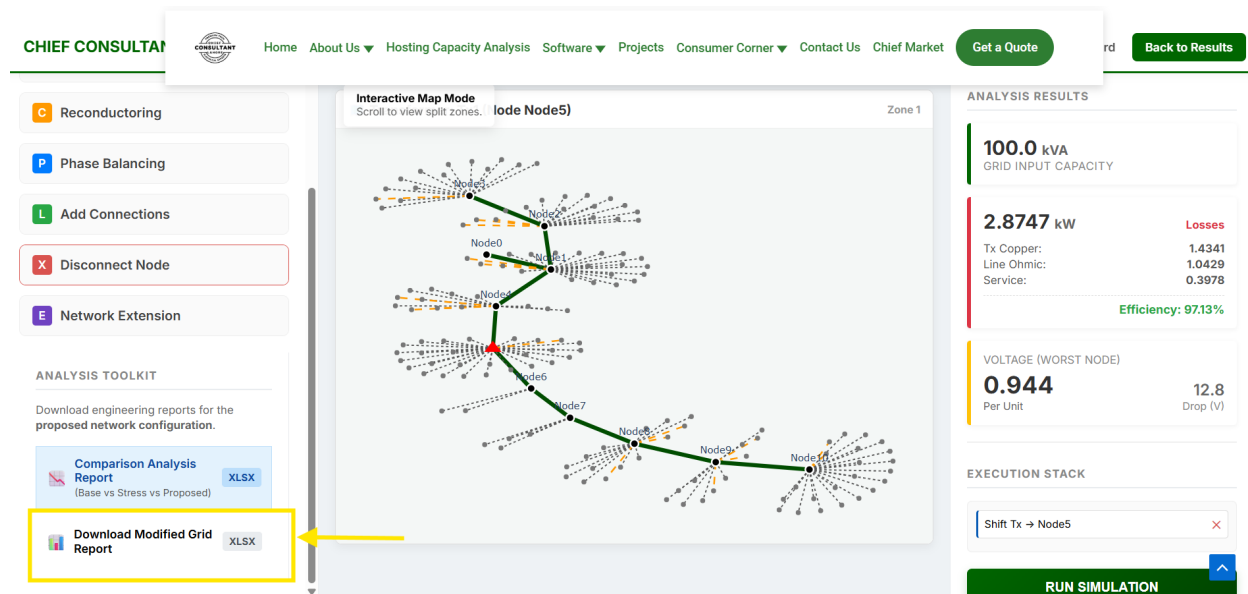


Figure 16.1: Planning Suite modified-grid report control.

Engineering_Report (1) [Protected View] - Excel

FILEHOMEINSERTPAGE LAYOUTFORMULASDATA REVIEWVIEW

PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to edit, it's safer to stay in Protected View. Enable Editing

A1

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Figure 16.2: Example modified-grid engineering XLSX columns.

Chapter 17

Compare existing, growth and proposed cases

Purpose. Place growth and investment alternatives in a common engineering comparison.

The *Comparison Analysis Report* opens a *Synergy Analysis* dialog with Load Factor (example 40%) and Growth Factor (example 1.27). The workbook compares EXISTING (Base), EXISTING (With Growth), PROPOSED (Tx1) and PROPOSED (Tx2) by transformer rating, phase currents, line losses, voltage drop, annual energy loss and transformer loading. For example, the displayed line losses are 3.6, 5.26, 1.07 and 4.49 kW respectively. Treat the proposed columns as separate transformer zones, not interchangeable whole-network totals.

17.1 Instantaneous versus annual metrics

If an annualization assumes a representative peak loss $P_{\text{loss,peak}}$ and a loss factor LF_{loss} , then $E_{\text{loss,year}} \approx P_{\text{loss,peak}} LF_{\text{loss}} 8760$. A load factor is not automatically a loss factor; the conversion depends on the adopted load shape and methodology. Record the software output and the planning factors used for annual energy estimates. Demand growth also changes I^2R nonlinearly; do not scale losses linearly without solving.

Operator procedure. Set load factor and growth factor from approved planning data; generate the workbook; verify which case each column represents; document how zone results are aggregated and the adopted annual-energy calculation. Pair electrical gains with capital cost and service reliability before selecting a plan.

Engineering note

The proposed Tx2 zone in Figure 17.3 carries a 10% voltage-drop entry and 77.5% transformer loading. Compare both proposed zones against the utility's criteria before selecting the combined plan.

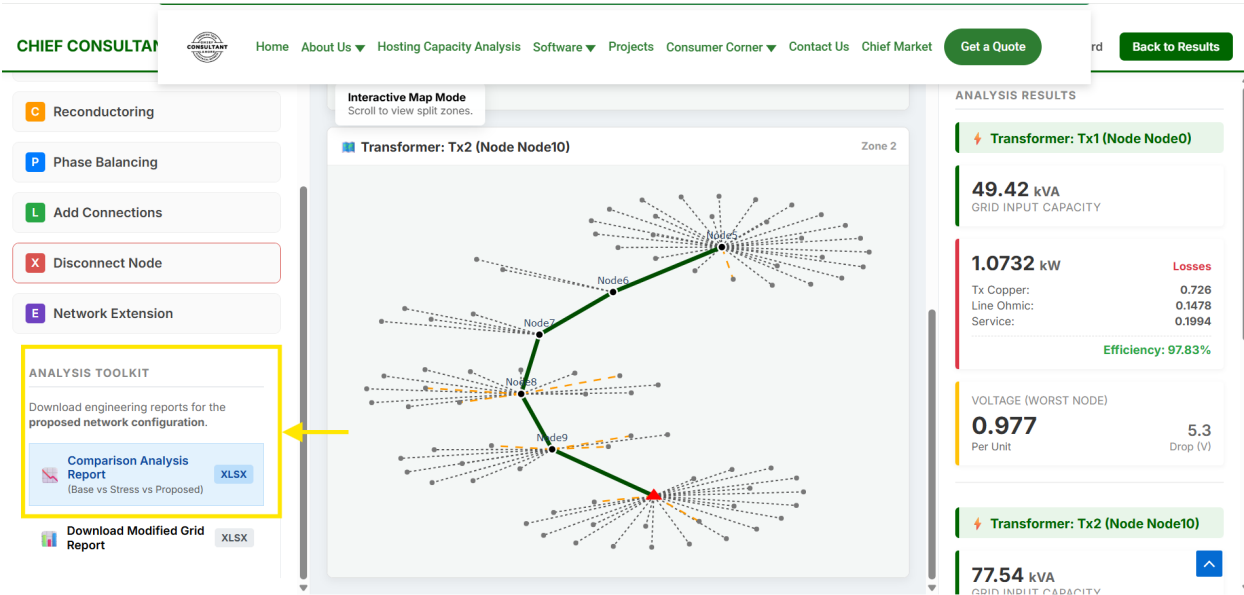


Figure 17.1: Comparison report option alongside two transformer zones.

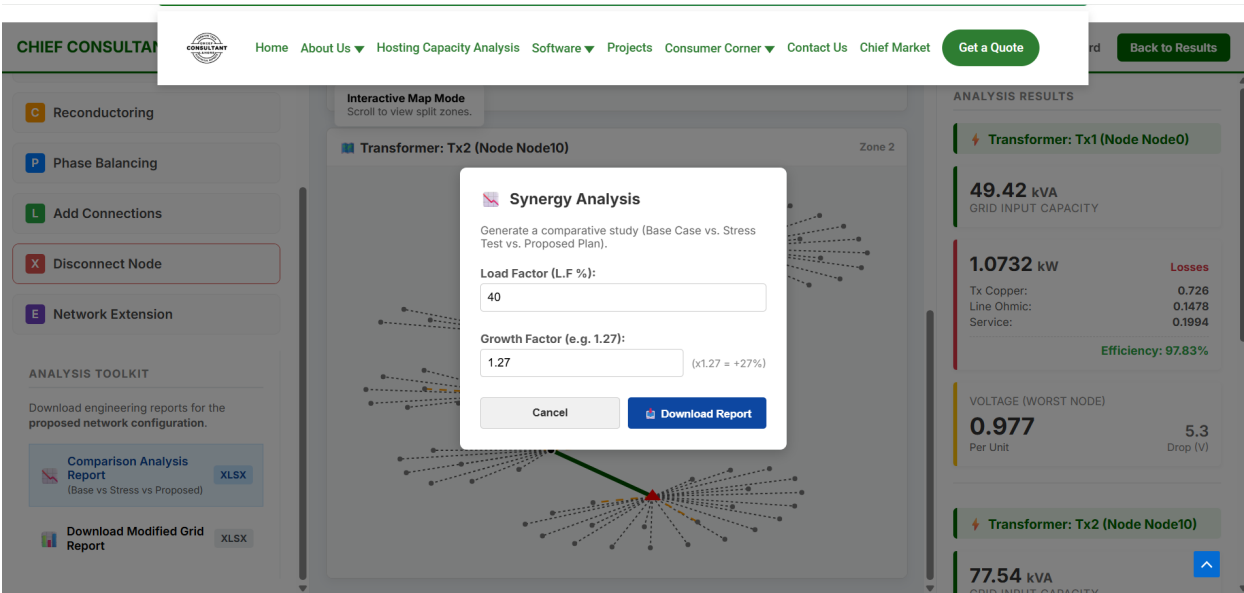


Figure 17.2: Synergy Analysis inputs: load and growth factors.

Excel ribbon: FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
 Synergy_Report_G1.27_LF40.0 [Protected View] - Excel
 PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to edit, it's safer to stay in Protected View. [Enable Editing](#)

	A	B	C	D	E	F
1	Parameter	EXISTING (Base)	EXISTING (With Growth)	PROPOSED (Tx1)	PROPOSED (Tx2)	
2	Transformer Rating (kVA)	200	200	200	100	
3	L.F (40.0%)	40	40	40	40	
4	Current Red (Amp)	92.9	114.8	47.5	70.3	
5	Current Yellow (Amp)	182.2	229.5	86.4	143.8	
6	Current Blue (Amp)	166	210.3	86.4	122.3	
7	Average Loading (Amp)	147	184.9	73.4	112.1	
8	Line Loss (kW)	3.6	5.26	1.07	4.49	
9	% Line Loss	4.01	4.6	2.41	6.44	
10	% V.D	8	10.1	2.3	10	
11	Annual Energy Loss (kWh)	7324	10681	2181	9131	
12	% Annual Energy Loss	2.32	2.67	1.4	3.73	
13	Transformer Loading %	50	63.5	24.7	77.5	
14						
15						
16						
17						
18						
19						

Figure 17.3: Example existing, growth and proposed comparison workbook.

Appendix A

Engineering method and reproducible studies

A.1 From field survey to electrical network

The workflow has five connected stages: capture the transformer and secondary assets; validate and import the structured survey; establish phase-specific loading from an upstream target or measured currents; solve the network; and compare an unchanged baseline with proposed actions. In the digital network, each line section connects named From and To nodes. A service cable connects the local LT supply point to a consumer meter or DER connection. The root supply is the distribution transformer. A GPS coordinate controls where an asset appears on a map; electrical connectivity comes from the node and section records.

A complete study dataset includes transformer nameplate and electrical data; conductor type, length, phases and neutral; consumer counts and phase assignment; service cable parameters; and the location and operating assumption of existing PV. Survey quality governs model quality. Before simulation, verify unique node identities, a continuous path to the source for each served load, physically plausible lengths and the correct phase connection for each service.

A.2 Loading strategy and allocation

Strategy 1 uses the upstream kVA loading basis. For a transformer rating S_{rated} and target percent λ , the target magnitude is represented conceptually by

$$S_{\text{target}} = \frac{\lambda}{100} S_{\text{rated}}. \quad (\text{A.1})$$

Strategy 2 uses simultaneous secondary phase currents I_R , I_Y and I_B . Where phase voltage and power factor are available, the active-power relationship for each phase is approximately

$$P_\phi = V_{\phi N} I_\phi \text{PF}_\phi, \quad \phi \in \{R, Y, B\}. \quad (\text{A.2})$$

The field register supplies the customer locations, load categories and phase connections over which the loading is distributed. In either strategy, check the solved transformer boundary against the selected loading input and review the distribution of current among R, Y and B. This is particularly important when solar generation changes the net current measured at the transformer. Record the measurement time and PV operating state so the simulated snapshot represents the intended field condition.

A.3 Unbalanced load flow

OpenDSS solves the configured electrical network at steady state. For phase ϕ , complex power is $S_\phi = V_\phi I_\phi^* = P_\phi + jQ_\phi$. The phase currents differ as a result of unequal consumer connections, PV

injection and conductor paths. Transformer, main-line and service-cable impedance cause voltage change and power loss. The result is reported at system, section and phase level. The DSS export provides a portable record of the generated simulation model.

A.4 Scenario comparison discipline

Start every study from a saved baseline. Change one parameter or a clearly named group of parameters, run again and compare the same operating condition. When removing PV, retain its associated customer load. When adding a PV site, specify its node, phase and service connection. When splitting a feeder, account for every customer in the two resulting transformer zones. When testing growth, preserve a growth-only stress case alongside each proposal. The Execution Stack is the record of staged modifications; export it together with the solved engineering results.

A.5 Incremental DER hosting studies

For a hosting study, begin with a defined operating condition and increase PV at the selected node or set of nodes in controlled steps. Re-solve after every step and test the applicable voltage, conductor, transformer, reverse-flow and protection criteria. The largest acceptable step is the hosting result under those assumptions. Report the starting network, location and phases, increment, PV control setting, governing limit and first rejected increment. A connection simulation at one PV size answers that connection question; a hosting assessment evaluates the limit across a sequence of sizes.

Appendix B

How to interpret technical and commercial benefits

B.1 Technical value

LT-LoadFlow links a physical asset to its electrical consequence. The survey creates a common network record; the unbalanced solution reveals unequal phase currents, weak voltage points and concentrated losses; the planning tools compare the effect of a new transformer, relocation, conductor replacement, new connection or extension; and the DER workspace quantifies the effect of current or proposed solar sites. The detailed export lets engineering teams trace each system KPI back to individual sections and phases.

B.2 Quantifying a proposal

Define the base and proposal boundaries before presenting a benefit. For an instantaneous loss comparison, $\Delta P_{\text{loss}} = P_{\text{loss,base}} - P_{\text{loss,proposal}}$ in kW. For an annual energy estimate, use a representative time series or a documented loss factor: $E_{\text{loss,year}} \approx P_{\text{loss,reference}} LF_{\text{loss}} \times 8760$ kWh. A load factor and a loss factor serve different purposes. For an investment case, combine avoided energy cost with construction cost, asset life, operations, customer service and risk. Retain the load, PV and source-voltage assumptions for every compared run.

Decision	LT-LoadFlow evidence	Complementary design input
Conductor replacement	Phase current, section loss and voltage drop	Ampacity, construction standard and cost.
Transformer relocation	Supply path, total loss and worst-node voltage	Site, 11 kV access, civil work and protection.
New PV connection	Node voltage, phase loading and loss change	Inverter, service, seasonal conditions and interconnection rules.
New customer	Service and upstream section response	Sanctioned load, diversity and service design.
Network split	Separate transformer zones and comparative workbook	Upstream supply, zone reliability and capital cost.

Appendix C

Engineering definitions and field checklist

C.1 Definitions

Grid input Apparent power at the modeled supply boundary, in kVA.

Real-power loss Power dissipated in modeled transformer, LT line and service elements, in kW.

Phase current RMS current on the Red, Yellow or Blue phase, in amperes.

Voltage per unit Voltage divided by the corresponding phase or line nominal base.

Worst node The reported node with the minimum voltage in the studied energized network.

Execution Stack The ordered list of staged planning modifications evaluated by Run Simulation.

DER Distributed energy resource, including a rooftop solar PV installation at a defined connection point.

The apparent-power total and real-power loss use different units. A useful real-power efficiency definition is $\eta = P_{\text{delivered}}/P_{\text{input}}$ for the same time and boundary. Report a loss-reduction percentage with its denominator: the base, proposed or no-solar loss as appropriate.

C.2 Pre-run checks

Data group	Engineering check
Transformer	Identifier, rating, connection, secondary voltage, impedance, tap and measured loading.
Topology	Unique nodes, connected sections, branch points and the correct source path.
Line and service	Length, conductor type, phases, neutral, service route and termination.
Consumers	Meter count, category, phase assignment, demand and diversity assumption.
Solar PV	Location, phase, capacity, operating output, direction and inverter settings.

Data group	Engineering check
Geographic data	Coordinates, survey accuracy and physically realistic route lengths.
Operating point	Simultaneous currents, voltage and power factor when available; date and time.
Record	Input revision, settings, exported model and reports, and named proposal.

C.3 Study completion checklist

1. Confirm that the imported consumer and asset counts match the field register.
2. Reconcile the simulated transformer boundary with the selected loading strategy.
3. Inspect the worst-voltage point, highest phase currents and largest loss-contributing sections.
4. Save the baseline reports before applying a planning modification.
5. Run each proposal and review all affected sections and transformer zones.
6. Export the modified-grid and comparison workbooks with clear scenario names.
7. Record the chosen design, assumptions and engineering sign-off.

Appendix D

Support and next steps

Engineers can begin with a single surveyed transformer, then expand the program across representative urban, suburban and rural networks. Chief Consultant can discuss survey onboarding, the data format, analysis settings, DER assessments, training and planning workflow integration with a utility team.

Explore LT-LoadFlow and request assistance

chiefconsultantpak.com/software/lt-loadflow/

Contact Chief Consultant Pakistan

About Chief Consultant Pakistan

Chief Consultant Pakistan develops engineering tools and provides power-sector consulting services. LT Unbalanced Precision Load Flow is designed for the practical decisions made below the distribution transformer: how to survey the network, understand its present electrical condition and test a proposed change before implementation. The system is designed by Engr. Muzammil Adeeb, Chief Software Developer at Chief Consultant. For current access and product assistance, use the official contact page above.