# *Distribution Loss Studies and Loss Reduction Techniques*

**Presentation to:**
**The National Commission for Energy State Regulation of Ukraine Energy**

**The Public Utility Commission of Ohio**

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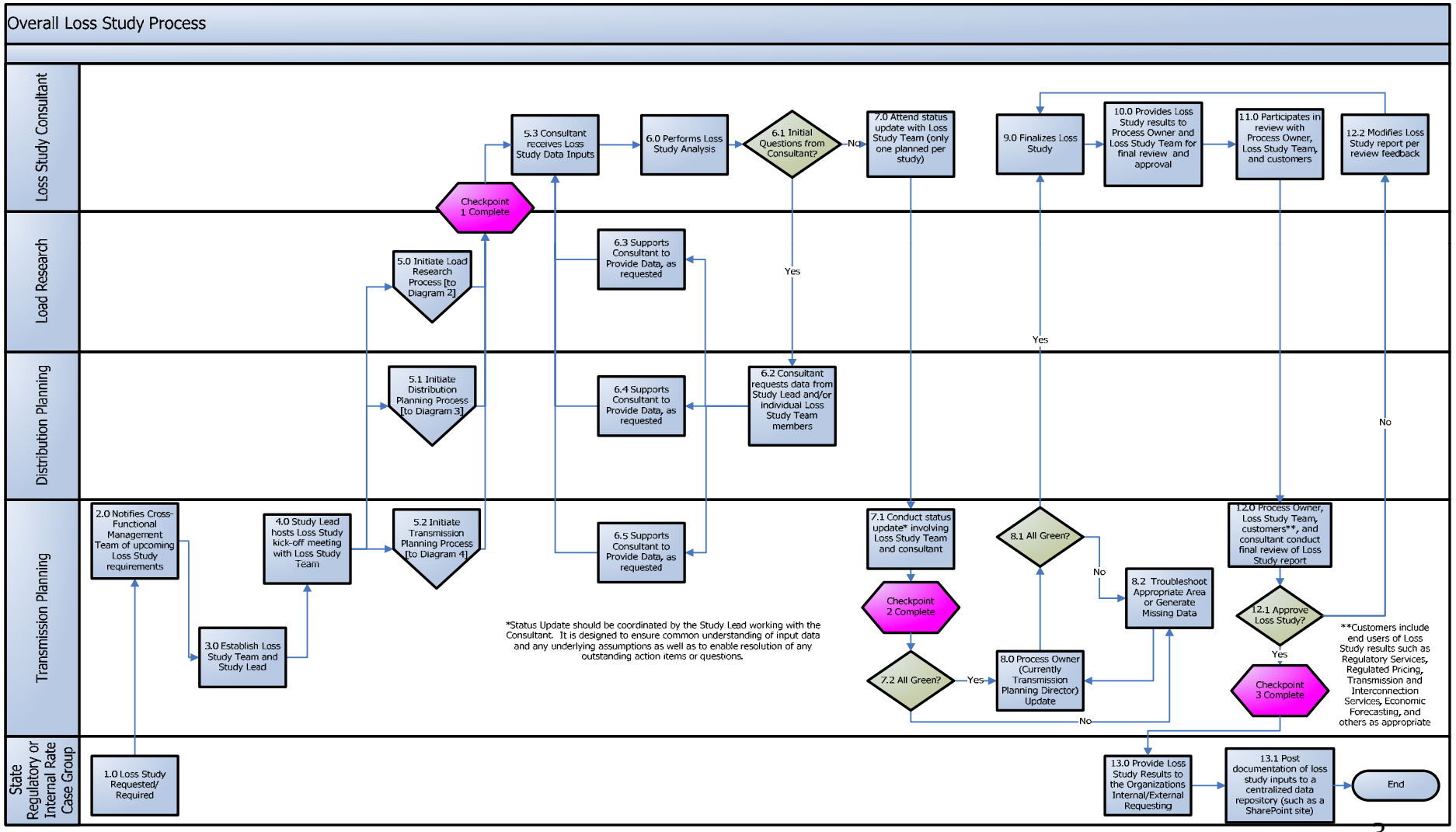
**Tom Weaver, PE**

# Loss Study Process Overview

- Typically, between five to ten percent of the total kilowatt hour (kWh) requirements of an electric utility is lost or unaccounted for in the delivery of power to customers.
- The objective of a loss study is to provide a reasonable set of energy (average) and demand (peak) loss expansion factors which account for system losses associated with the transmission and delivery of power to each voltage level over a designated period of time.
- Identify the difference between total energy inputs and associated sales.
- The resulting difference between these values must be allocated equitably between the transmission and distribution delivery systems.
- AEP has a documented, repeatable corporate wide process.
- Transmission Planning is the loss study process owner and works with cross functional management team to initiate loss studies when requested.
- Employees from Load Research, Transmission Planning, and Distribution Planning provide the energy, demand, and system metrics inputs.
- AEP contracts an independent consultant to complete the total system loss analysis study with the data provided by AEP loss study teams.

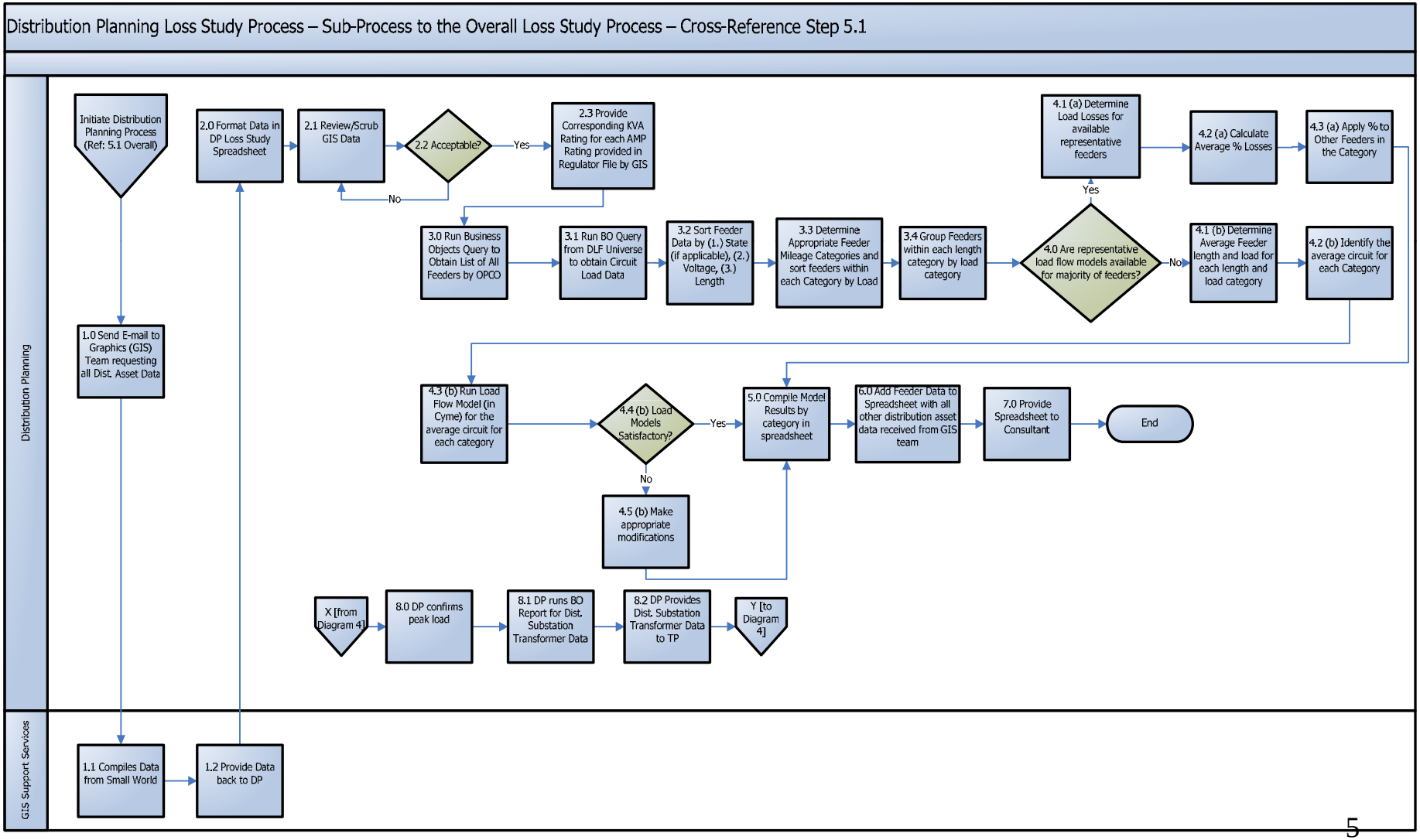
# AEP Loss Study Process Map



# AEP Loss Study Process Steps Overview

| Step Description | Process Details / Narrative |
|---|---|
| 1. Loss Study Requested/Required | Loss Study Process Owner receives request from Regulatory Services, Regulated Pricing, or other Loss Study customer for a new Loss Study. |
| 2. Notifies Cross-Functional Management Team of upcoming Loss Study requirements | Process Owner notifies Cross-Functional Management Team of need for new Loss Studies. Cross-Functional Management Team provides input for establishing priorities and schedule. |
| 3. Establish Loss Study Team and Study Lead | Loss Study Team is selected based on input from Cross-Functional Management Team. Process Owner selects Study Lead. |
| 4. Study Lead hosts Loss Study kick-off meeting with Loss Study Team | The purpose of this kick-off meeting is to establish communication between the participants in a given loss study, determine study parameters, establish overall schedule and input data due dates, and address any other initial questions. |
| 5. Initiate Load Research Process | Represents the first step of the Load Research Sub-Process. |
| 6. Initiate Distribution Planning Process | Represents the first step of the Distribution Planning Sub-Process. |
| 7. Initiate Transmission Planning Process | Represents the first step of the Transmission Planning Sub-Process. |
| 8. Consultant receives Loss Study Data Inputs | Loss Study Team participants from each function provide initial data to consultant with copy to Team Lead. |
| 9. Performs Loss Study Analysis | Consultant performs preliminary analysis to determine reasonableness of input data. |
| 10. Troubleshoot Appropriate Area or Generate Missing Data | Loss Study Team is assigned the task of resolving any outstanding issues, with appropriate support provided by the Process Owner and the Cross-Functional Management Team. |
| 11. Finalizes Loss Study | Consultant finalizes Loss Study and prepares report. |

# AEP Loss Study Distribution Process Map



# AEP Loss Study
# Distribution Planning Process Steps

| Process Step | Step Description | Process Details/Narrative | Additional information |
|---|---|---|---|
| 1.0 | Send E-mail to Graphics (GIS) Team requesting all Dist. Asset Data | Request distribution circuit asset data reports from GIS Office. Notify GIS of need for distribution asset data from Smallworld to support jurisdictional loss study and agree on deadline to support overall loss study requirements. | Distribution asset data should include line voltage regulators (# of by voltage and size), capacitors (# of by circuit, size, type) line transformers (# of units and banks, by type, size), secondary conductor (length of in conductor feet and wire feet by size, type), services (# of by type, size, code). |
| 2.0 | Format Data in DP Loss Study Spreadsheet Review/Scrub GIS Data | Distribution planning will check data provided by GIS for reasonableness using their knowledge of the system that the loss study is being run on and the types of equipment installed Outlying equipment should be checked individually and deleted if found to be in error. | 1- Compare total feeder loading to total transformer kVA.<br>2- Check regulators for standard sizes and voltages and number based on system knowledge<br>3- Check number and size of capacitor banks based on system knowledge |
| 3.0 | Run Business Objects Query to Obtain List of All Feeders by OPCO | Run query on Distribution Common Entity database to get feeder designations, voltage class and circuit length. | Feeders not in the database for some reason can be added to obtain a true depiction of the system for the loss study period. Fields in Query should include, at a minimum, CktID, Station, Circuit, Voltage, ST, SW Voltage, OH Primary Miles, UG Primary Miles, and Total Ckt Miles. |
| 4.0 | Are representative load flow models available for majority of feeders? | Load flow cases available from normal planning and operations work can be used to determine the losses on feeders. Load flows should be selected for use based on how well they represent the load and losses on the feeder at the time of the peak for the loss study using engineering judgment | Generally, load flows prepared within the last 2 to 3 years for which there has been no system reconfiguration or change in main line conductor would be representative. |
| 5.0 | Compile Model Results by category in spreadsheet | Sum load and losses for all feeders in study to a single percentage loss to be applied by voltage level. | The loss study applies a single loss percentage to the primary within each voltage class. The load may be scaled up or down to match the sales and load research load information that indicates the loading on the distribution primary feeder system |
| 6.0 | Add Feeder Data to Spreadsheet with all other distribution asset data received from GIS team | Combine results of feeder primary loss study results with distribution circuit asset data into single spreadsheet workbook with data on individual worksheet tabs. | |
| 7.0 | Provide Spreadsheet to Consultant | Send data in electronic file to consultant performing loss study | Include input data and calculations and leave spreadsheet unprotected |
| 8.0 | DP confirms peak load | Match transformer loadings from DLF or CSII to list of substation transformers | |

# Examples of Distribution Data Provided to Consultant for Loss Study*

**APCo - VA**

| Description | 34.5 kV - Long (> 70 miles) | 34.5 kV - Medium (18-70 miles) | 34.5 kV - Short (< 18 miles) | 12 kV - Long (> 70 miles) | 12 kV - Medium (18-70 miles) | 12 kV - Short (< 18 miles) | 4 kV - All |
|---|---|---|---|---|---|---|---|
| Average Feeder Length | 160.00 | 35.00 | 8.00 | 97.00 | 30.00 | 7.00 | n/a |
| Average Feeder Load (KVA) | 11000 | 9500 | 6500 | 7000 | 6000 | 5000 | n/a |
| Calculated Losses* (kW) | 300 | 45 | 40 | 200 | 100 | 50 | n/a |
| Total Numbers of Feeders | 70 | 40 | 10 | 60 | 160 | 150 | n/a |

* Per Cyme Models

**APCO - Virginia**

**Description:** Secondary conductors by various sizes, OH & UG

| OH/UG | State | Size | Conductor Feet | Wire Feet | Conductor Miles | Wire Miles |
|---|---|---|---|---|---|---|
| OH | Virginia | 1 | 2,561.07 | 3,887.27 | 0.5 | 0.7 |
| OH | Virginia | 1/0 | 10,744,278.00 | 21,231,744.78 | 2,034.9 | 4,021.2 |
| OH | Virginia | 1000 | 117.85 | 353.56 | 0.0 | 0.1 |
| OH | Virginia | 2 | 7,500,236.14 | 14,081,314.49 | 1,420.5 | 2,666.9 |
| OH | Virginia | 2/0 | 98,449.82 | 237,498.31 | 18.6 | 45.0 |
| OH | Virginia | 2A | 1,812.79 | 2,873.67 | 0.3 | 0.5 |
| OH | Virginia | 3/0 | 216,094.31 | 369,034.02 | 40.9 | 69.9 |
| OH | Virginia | 300 | 90.86 | 272.57 | 0.0 | 0.1 |
| OH | Virginia | 336 | 131,665.68 | 349,647.78 | 24.9 | 66.2 |
| OH | Virginia | 350 | 2,843.50 | 7,736.96 | 0.5 | 1.5 |
| OH | Virginia | 4 | 9,059,436.13 | 12,488,712.55 | 1,715.8 | 2,365.3 |
| OH | Virginia | 4/0 | 4,496,612.21 | 8,963,992.39 | 851.6 | 1,697.7 |
| OH | Virginia | 4A | 53,742.36 | 88,363.88 | 10.2 | 16.7 |
| OH | Virginia | 500 | 796.71 | 2,301.18 | 0.2 | 0.4 |
| OH | Virginia | 556 | 1,584.00 | 4,224.38 | 0.3 | 0.8 |
| OH | Virginia | 6 | 438,088.11 | 802,109.04 | 83.0 | 151.9 |
| OH | Virginia | 6A | 31,871.84 | 51,424.82 | 6.0 | 9.7 |
| OH | Virginia | 750 | 232.73 | 741.17 | 0.0 | 0.1 |
| OH | Virginia | 8 | 7,955.95 | 14,167.10 | 1.5 | 2.7 |
| OH | Virginia | Unknown | 421,096.30 | 455,692.36 | 79.8 | 86.3 |

**APCO - VA**

**Description:** Overhead pole mounted distribution circuit voltage regulators.

| Voltage (kV) | Rating (Amps) | Rating (KVA) | In-Service |
|---|---|---|---|
| 12 kV | 50 | | 180 |
| 12 kV | 75 | | 75 |
| 12 kV | 100 | | 500 |
| 12 kV | 150 | | 15 |
| 12 kV | 167 | | 25 |
| 12 kV | 200 | | 0 |
| 12 kV | 201 | | 15 |
| 12 kV | 219 | | 175 |
| 12 kV | 328 | | 100 |
| 12 kV | 400 | | 5 |
| 12 kV | 438 | | 5 |
| 12 kV | Unknown | | 5 |
| 34 kV | 50 | | 5 |
| 34 kV | 100 | | 10 |
| 34 kV | 167 | | 5 |
| 34 kV | 200 | | 5 |
| | | **Total APCO - VA** | **1,125** |

**Description:** Pole mounted - overhead distribution line transformers - includes both service and main line step-down transformers, single and three phase

**APCO - VA**

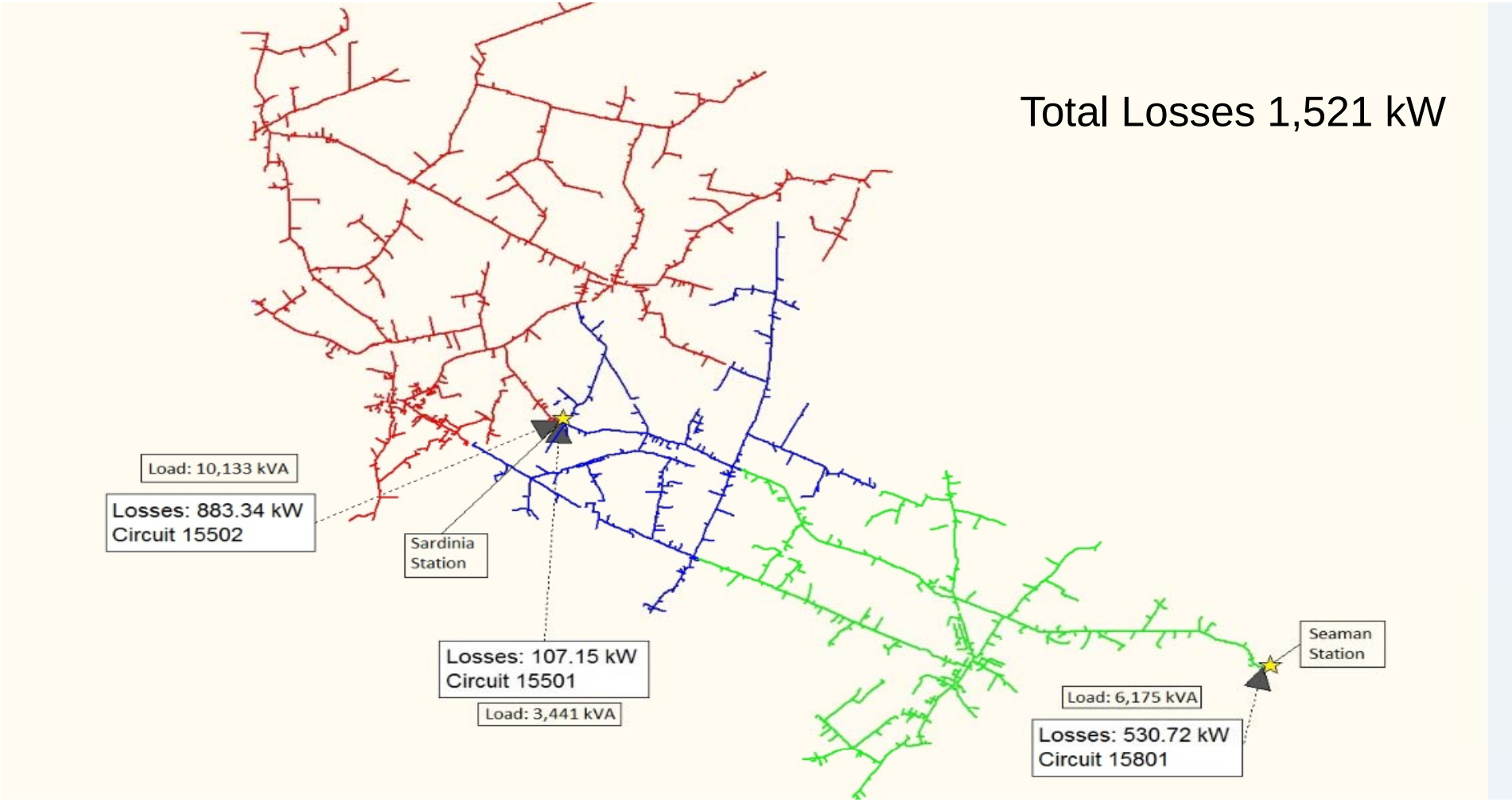
| OH/UG | KVA | Number of Banks | Number of Units |
|---|---|---|---|
| OH | 0.5 | 5 | 5 |
| OH | 1.5 | 120 | 125 |
| OH | 3 | 1,400 | 1,400 |
| OH | 5 | 4,000 | 4,000 |
| OH | 7.5 | 190 | 200 |
| OH | 10 | 36,000 | 37,000 |
| OH | 15 | 55,000 | 56,000 |
| OH | 22.5 | 1 | 1 |
| OH | 25 | 66,000 | 70,000 |
| OH | 37.5 | 11,000 | 12,000 |
| OH | 50 | 18,000 | 22,000 |
| OH | 75 | 4,000 | 5,000 |
| OH | 100 | 1,500 | 3,000 |
| OH | 112.5 | 1 | 1 |
| OH | 150 | 5 | 10 |
| OH | 167 | 800 | 1,500 |
| OH | 250 | 500 | 600 |
| OH | 300 | 1 | 1 |
| OH | 333 | 250 | 300 |
| OH | 500 | 600 | 750 |
| OH | 667 | 3 | 5 |
| OH | 750 | 1 | 5 |
| OH | 1,000 | 5 | 10 |
| OH | 1,500 | 2 | 5 |
| OH | 3,750 | 1 | 1 |
| OH | 5,000 | 1 | 1 |
| OH | Unknown | 300 | 300 |
| | **Totals APCO - VA** | **199,687** | **214,220** |

***Actual values have been modified and values shown are just for representative purposes.**

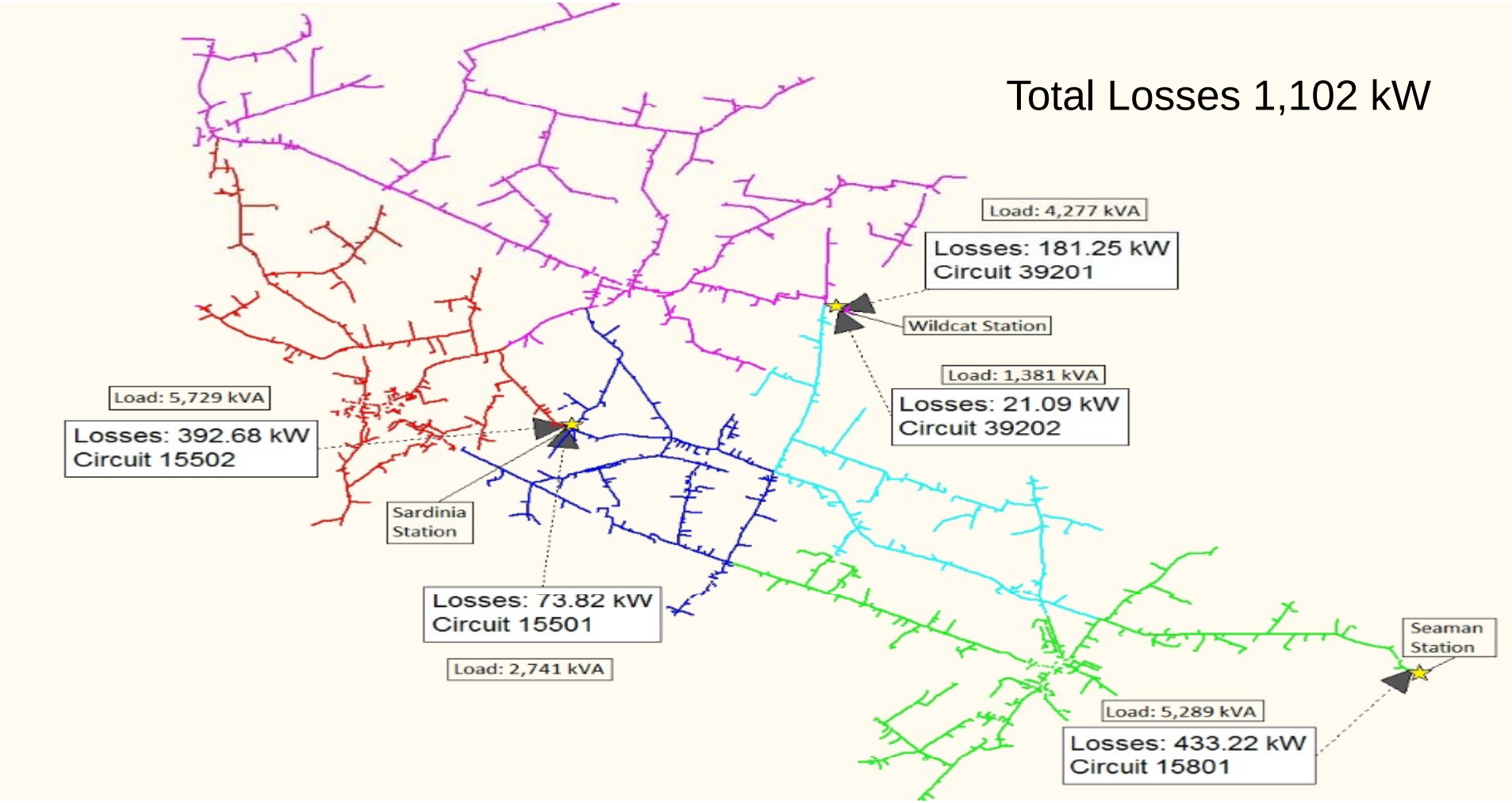
# Example Loss Study Results

| | Total | Delivery System (Excludes Transmission) |
|---|---|---|
| **Demand (kw)** | | |
| Transmission | 1.02055 | - |
| Subtransmission | 1.04188 | 1.02090 |
| Primary Lines | 1.05057 | 1.02941 |
| Secondary | 1.07454 | 1.05290 |
| | | |
| **Energy (kwh)** | | |
| Transmission | 1.01422 | - |
| Subtransmission | 1.02887 | 1.01445 |
| Primary Lines | 1.03884 | 1.02428 |
| Secondary | 1.06703 | 1.05207 |
| | | |
| Losses - Net System Input | 4.99% MWh | |
| | 6.09% MW | |
| Losses - Net System Output | 5.25% MWh | |
| | 6.49% MW | |

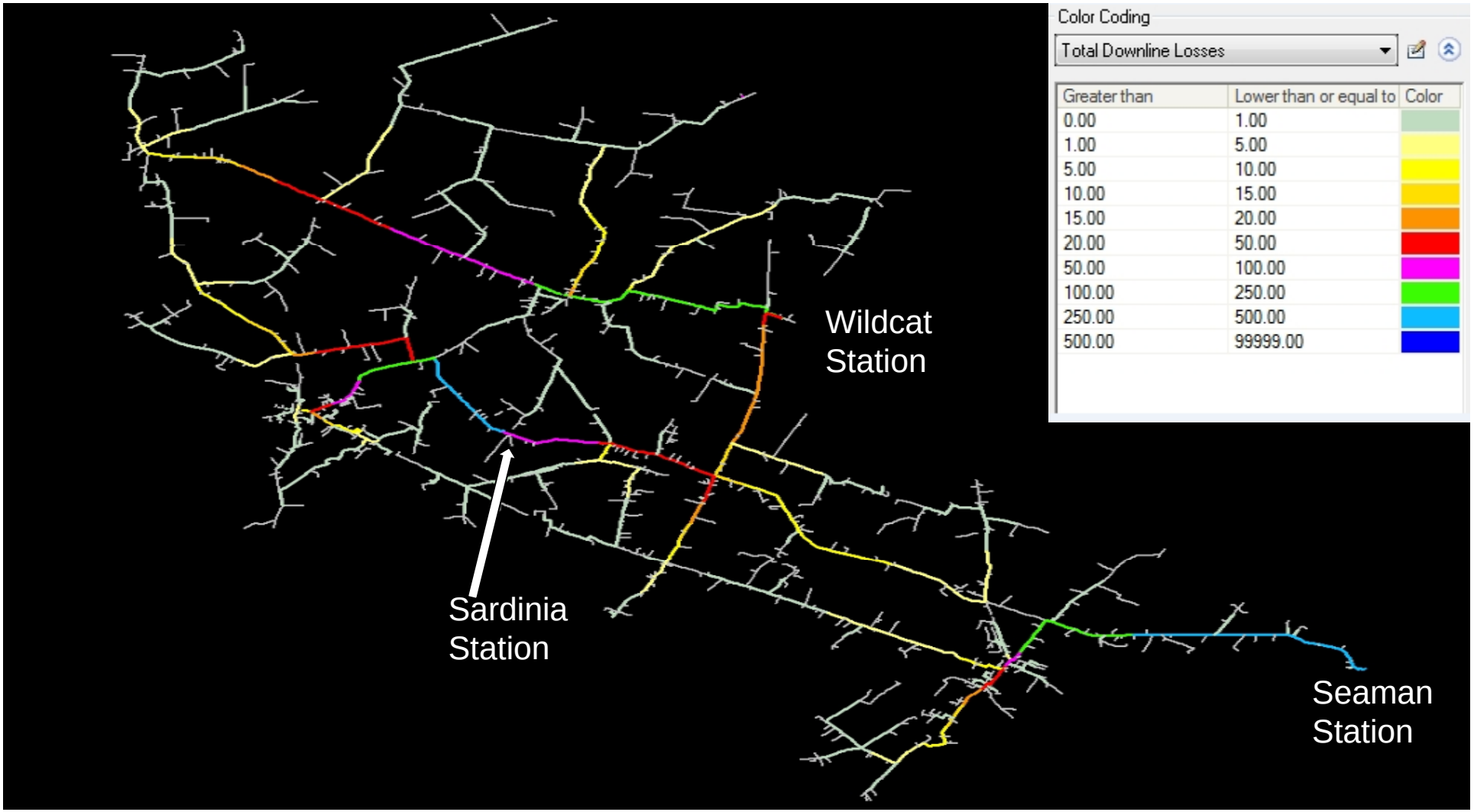
# Loss Reduction Example
# Before New Station and Circuits



# Loss Reduction Example
# After New Station and Circuits



# Graphic Loss Analysis



# Loss Reduction Techniques
# Circuit Improvements

- Phase balancing by re-phasing taps
- Load balancing across phases
- Improving power factor close to unity
- Locating large loads near the substation
- Reducing circuit lengths / adding new circuits
- Re-conductoring to larger wire size

# Loss Reduction Techniques
# Technology Improvements

- **Volt VAR Optimization (VVO)** – Monitoring of reactive power load (VARs) and near real time control of capacitor banks can optimize the power factor at the circuit level.

# Electric Power Research Institute (EPRI) Green Circuits Report

- AEP participated in the Green Circuits project which studied loss reduction and energy efficiency on circuits of participating utilities in the U.S.
- *Green Circuits: Distribution Efficiency Case Studies.* EPRI, Palo Alto, CA: 2011.
- Report available @ EPRI.COM Report #1023518

# Questions?

Tom Weaver – tfweaver@aep.com