ELECTRIC SYSTEM STUDY & CAPITAL IMPROVEMENTS PLAN

PRINCETON PUBLIC UTILITIES

Andy Koob, PE

DGR ENGINEERING

ABOUT US

- Andy Koob, PE
  - BSEE, SDSU – 2002
  - Project Manager
- Electrical Power Department
  - DGR Engineering – Rock Rapids, Iowa

OUR TASKS

- System evaluation and planning study
- <u>PPU's internal system:</u>
  - 69 kV Transmission System (GRE)
  - Substations (3)
  - 12.47 kV & 4.16 kV Distribution System
  - Power Plant (generation capacity only)
- Analyze existing and any proposed system under present (2021) and future (2031) loads
- Covers a 10-year period to 2031

OUR GOALS

- Identify deficiencies
- Recommend improvements to eliminate those deficiencies
- Provide cost estimates for fiscal planning

EXISTING SYSTEM

- 69 kV Transmission System:
  - North Feed, GRE-Owned, ~23 Miles Long
    - Serves North Substation
    - Operated "Closed-Loop"
  - South Feed, SMMPA-Owned, ~2.77 Miles Long
    - Serves Power Plant & South Substations
    - Radial Feed back to GRE System

EXISTING SYSTEM

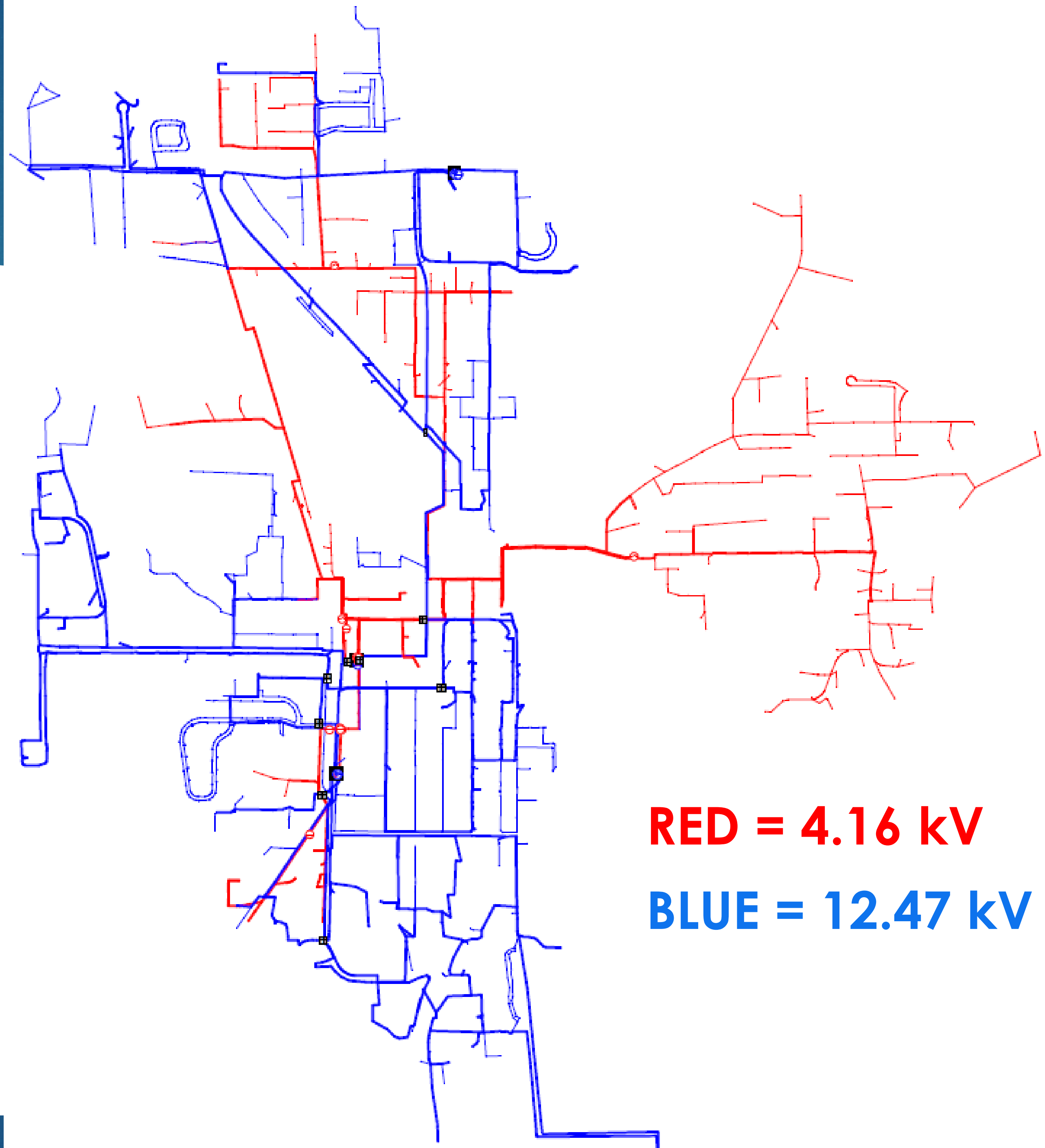
- (3) Substations:
  - North Substation:
    - (2)69-12.47 kV Power Transformers, 7 MVA*
      - * (1) Unit is offline due to gassing issues
    - Serves 12.47 kV Load

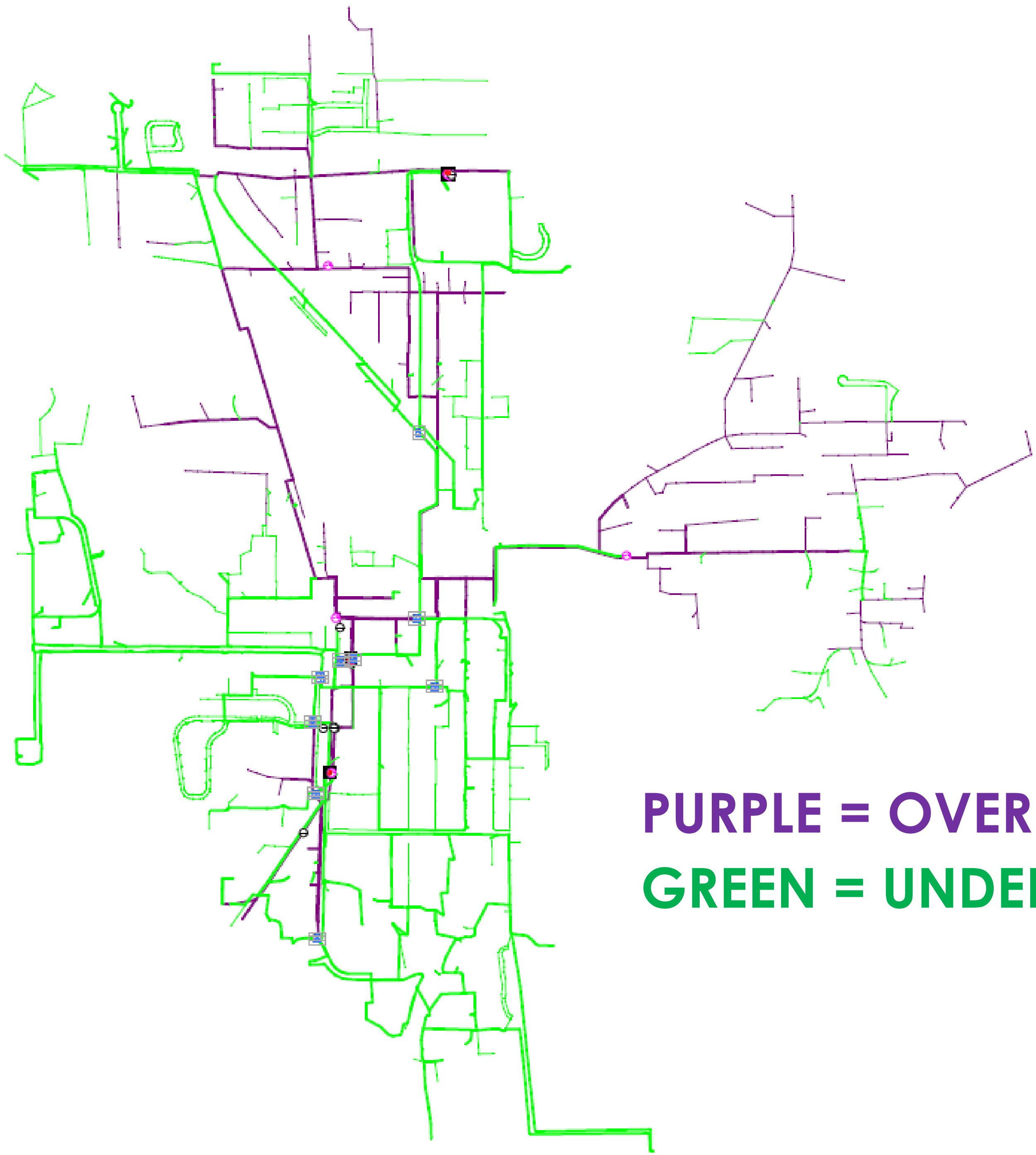
EXISTING SYSTEM

- <u>(3) Substations - Continued:</u>
  - Power Plant Substation:
    - (1) 69-4.16 kV Power Transformer, 10.5 MVA
    - (1) 4.16 kV – 12.47 kV Bus-Tie Transformer
    - Serves both 12.47 kV & 4.16 kV Load
  - South Substation:
    - (1) 69-12.47 kV Power Transformer, 28 MVA
    - (1) 12.47 kV – 4.16 kV Bus-Tie Transformer
    - Serves both 12.47 kV & 4.16 kV Load

EXISTING SYSTEM

- Distribution System:
  - 12.47 kV: (13) circuits, serves 73% of the Load
  - 4.16 kV: (5) circuits, serves 27% of the Load
  - Majority underground construction type


RED = 4.16 kV
BLUE = 12.47 kV



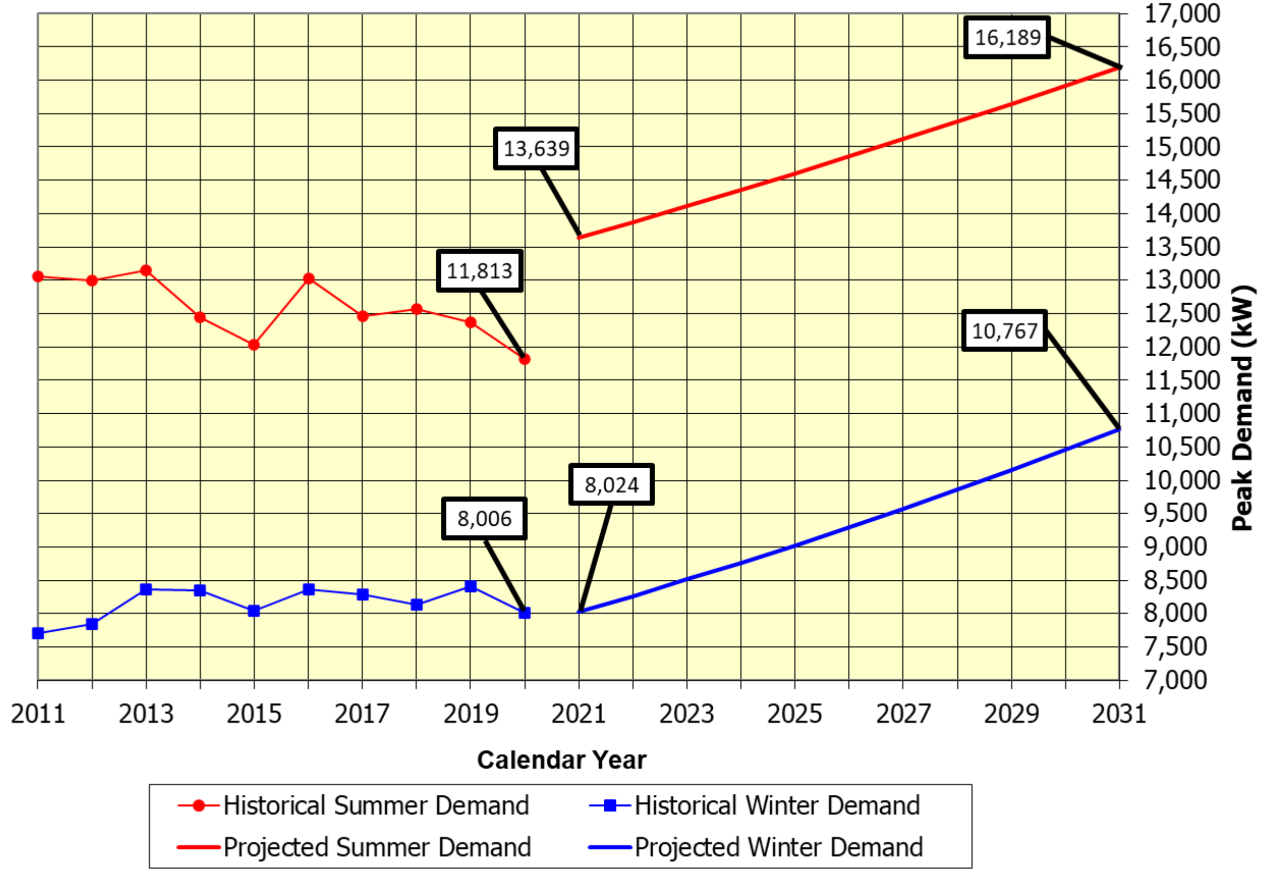
PURPLE = OVERHEAD

GREEN = UNDERGROUND

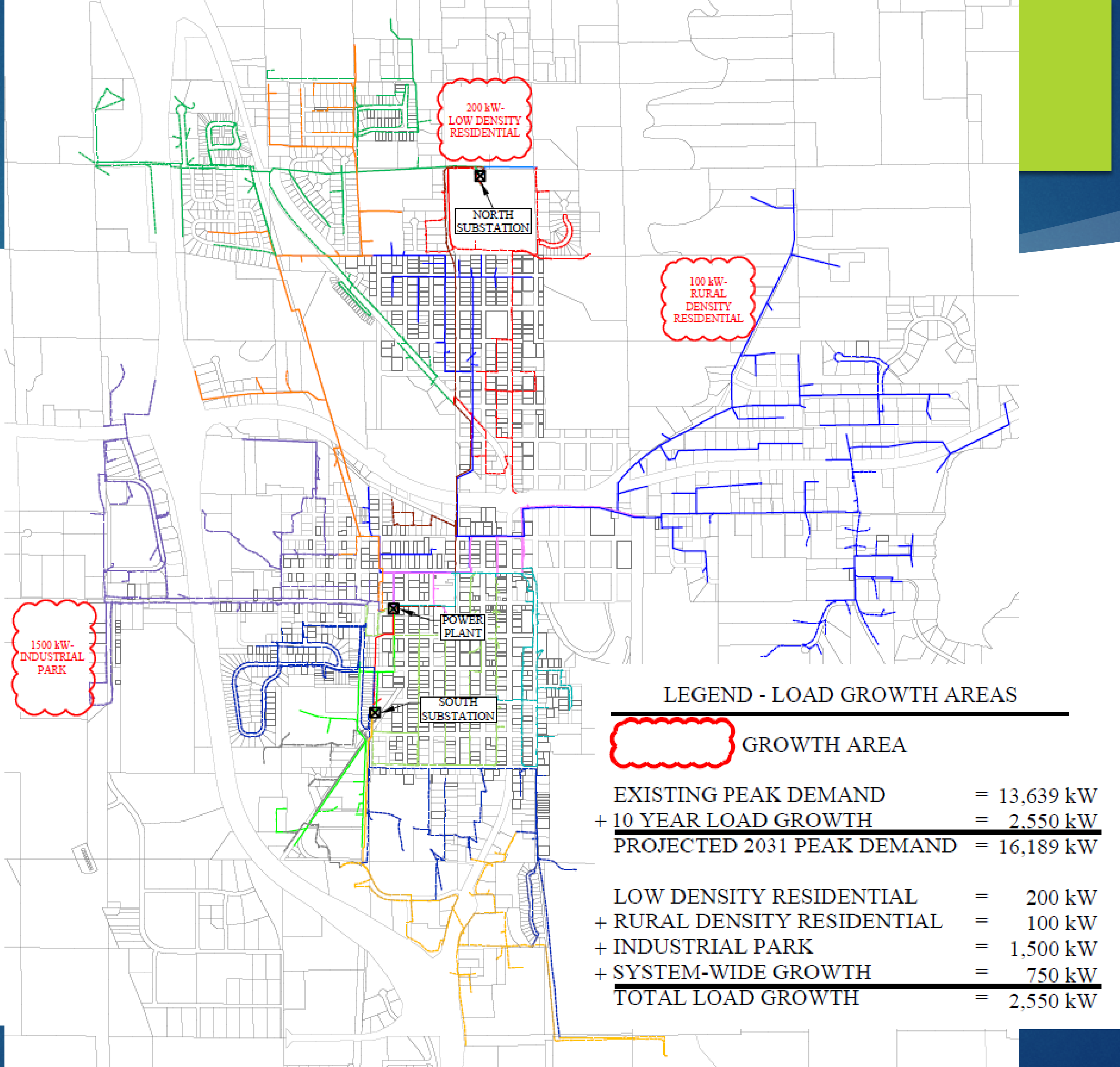
EXISTING SYSTEM

- <u>Generation at Power Plant:</u>
  - (5) diesel generators:
    - #3 – Fairbanks-Morse – 2,400 kW (1977)
    - #4 – Enterprise – 1,200 kW (1967)
    - #5 – Superior – 1,000 kW (1953)
    - #6 – Enterprise – 2,750 kW (1963)
    - #7 – Caterpillar – 4,840 kW (2002)
  - ~12,190 kW of total generating capacity

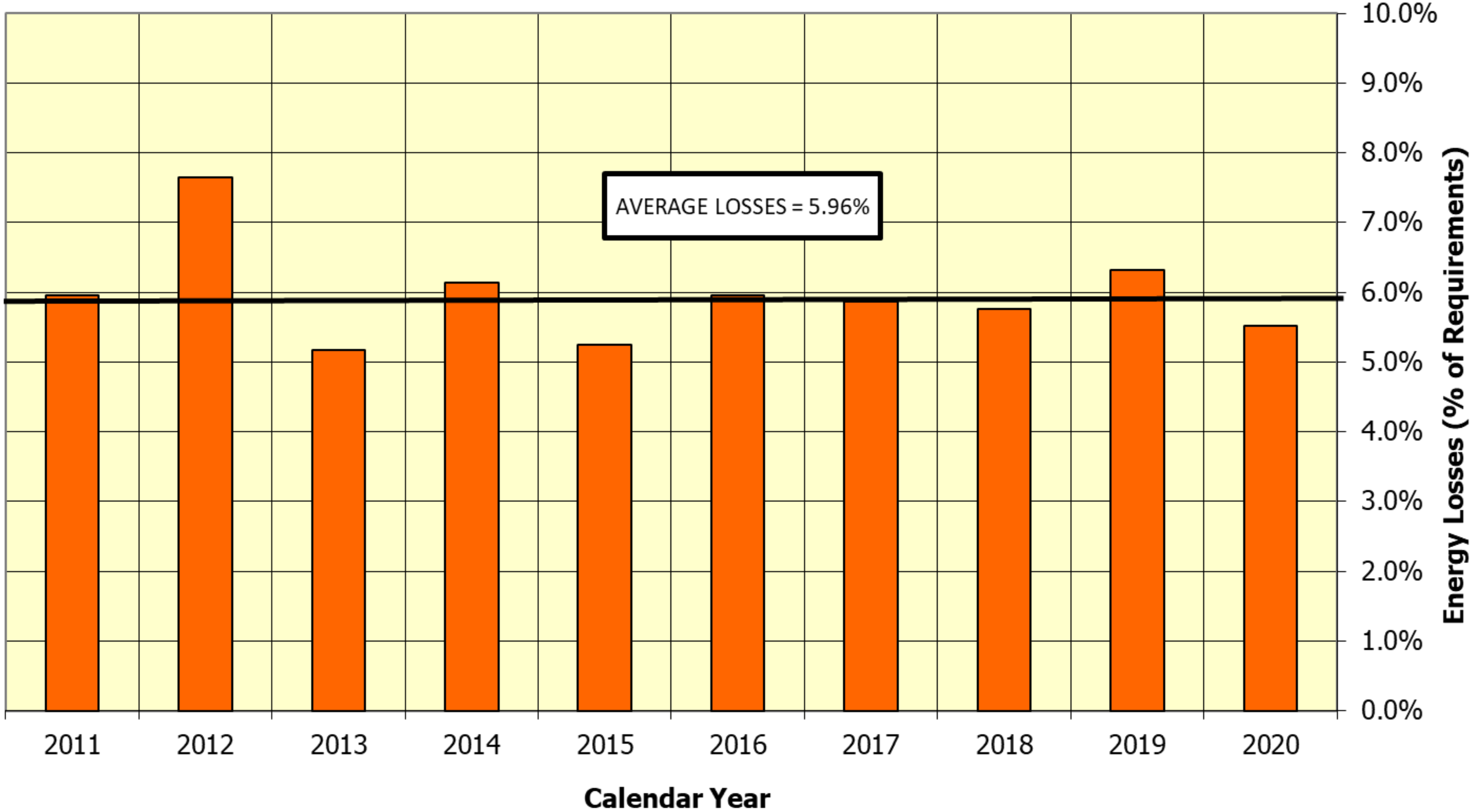
HISTORICAL AND FUTURE LOAD



- Annual Growth Rates (Projected): Summer = 1.73%; Winter = 2.98%

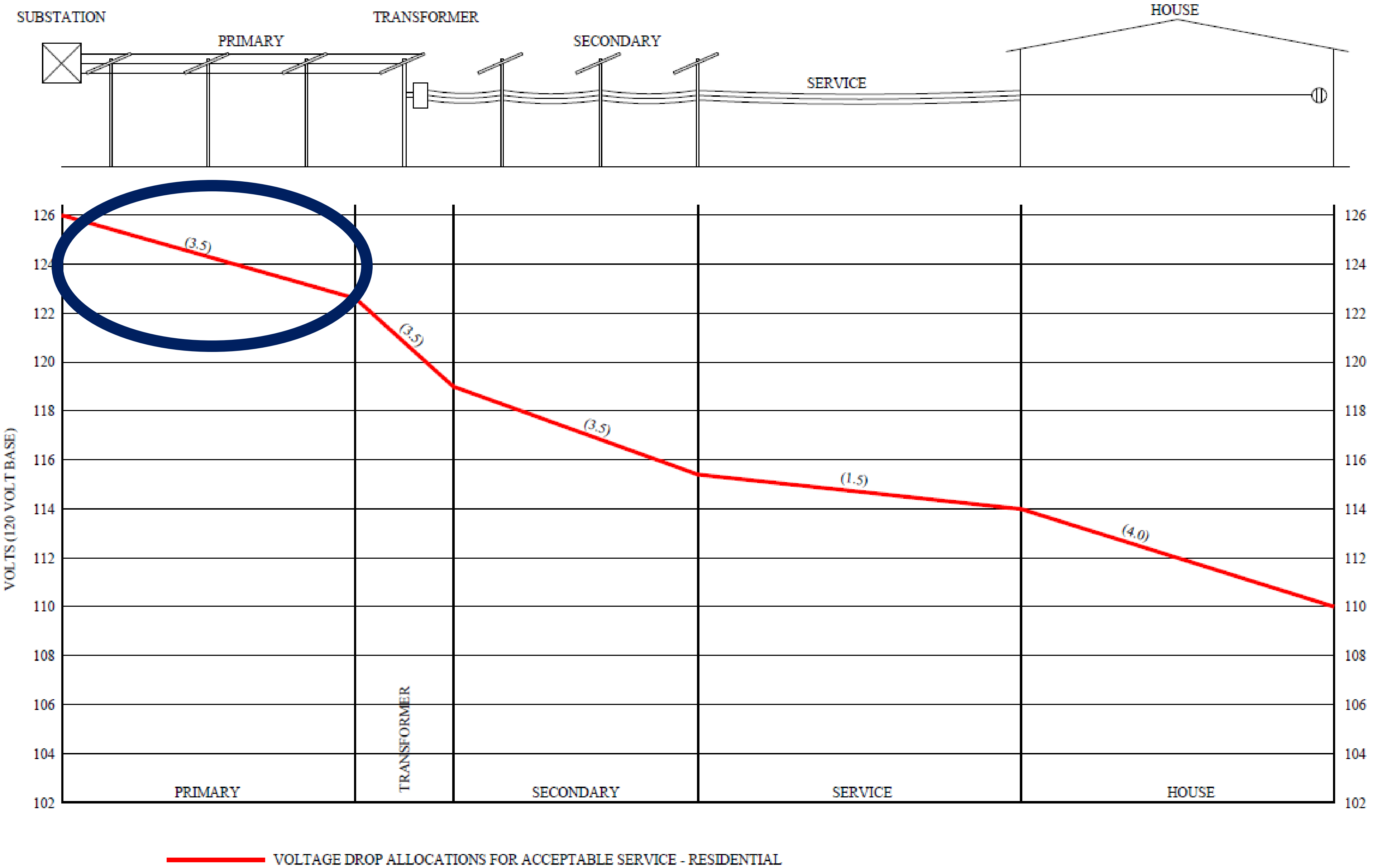

200 kW-
LOW DENSITY
RESIDENTIAL
NORTH
SUBSTATION
100 kW-
RURAL
DENSITY
RESIDENTIAL
POWER
PLANT
1500 kW-
INDUSTRIAL
PARK
SOUTH
SUBSTATION
LEGEND - LOAD GROWTH AREAS
GROWTH AREA
EXISTING PEAK DEMAND = 13,639 kW
+ 10 YEAR LOAD GROWTH = 2,550 kW
PROJECTED 2031 PEAK DEMAND = 16,189 kW
LOW DENSITY RESIDENTIAL = 200 kW
+ RURAL DENSITY RESIDENTIAL = 100 kW
+ INDUSTRIAL PARK = 1,500 kW
+ SYSTEM-WIDE GROWTH = 750 kW
TOTAL LOAD GROWTH = 2,550 kW

SYSTEM ENERGY LOSSES



DESIGN CRITERIA

- **Criterion #1** -- Provide "N-1" (single contingency) level of reliability for all transmission, substation, and distribution facilities.
- **Criterion #2** – Provide ANSI "Class A" voltage service to all customers, under normal or emergency conditions.



VOLTAGE DROP PROFILE CRITERIA

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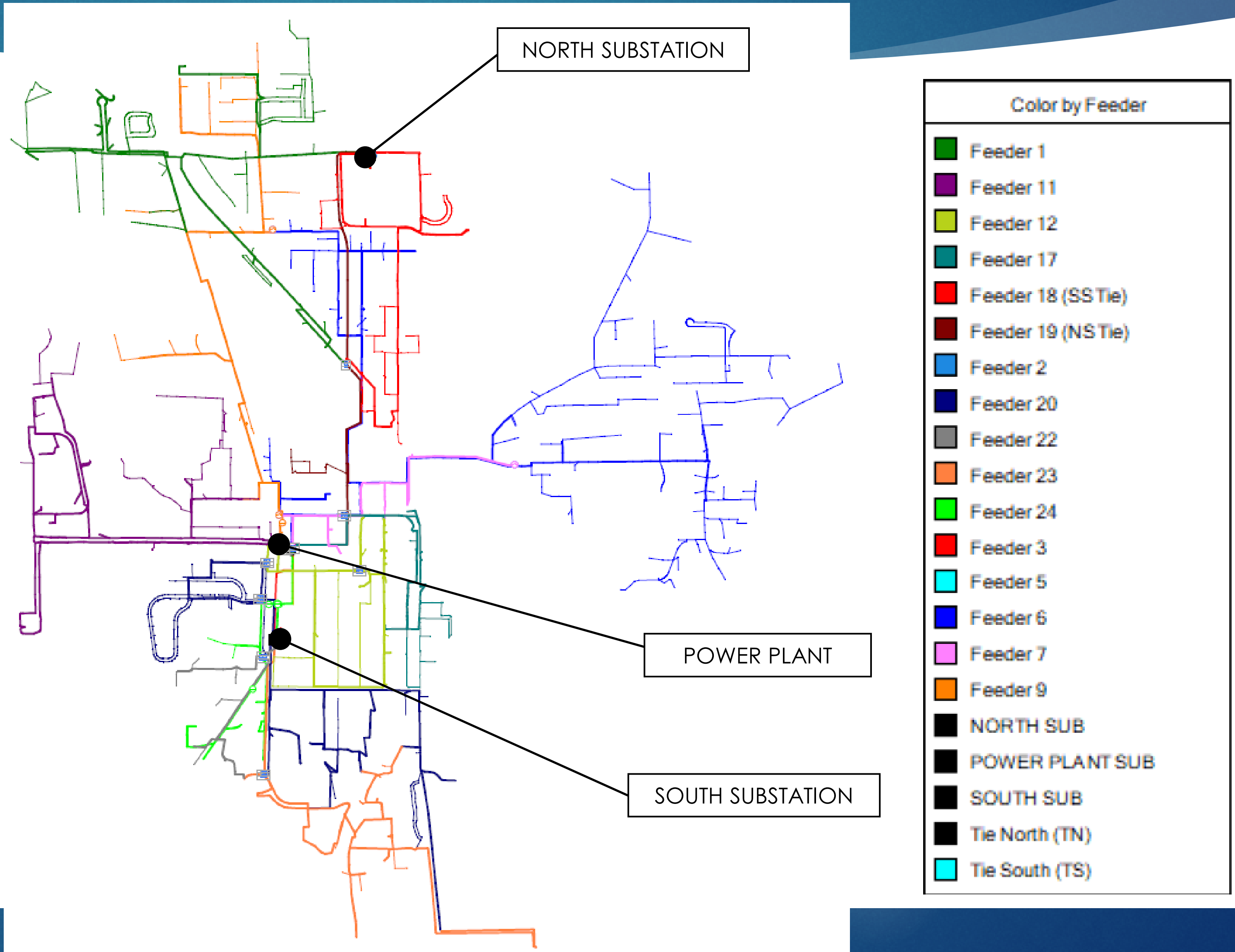
DESIGN CRITERIA

- **Criterion #1** – Provide "N-1" (single contingency) level of reliability for all transmission, substation, and distribution facilities.
- **Criterion #2** – Provide ANSI "Class A" voltage service to all customers, under normal or emergency conditions.
- **Criterion #3** – Do not exceed thermal limitations of facilities on the electric system, under normal or emergency conditions in order to not exceed established equipment ratings.
- **Criterion #4** – Flexible and easily expandable system.

SYSTEM ANALYSIS

- Software analysis – Milsoft's Windmil®
  - Built based on existing system configuration
  - Load flow modeling
  - Voltage and capacity analysis
  - System intact and emergency conditions
  - During existing and future loading configurations

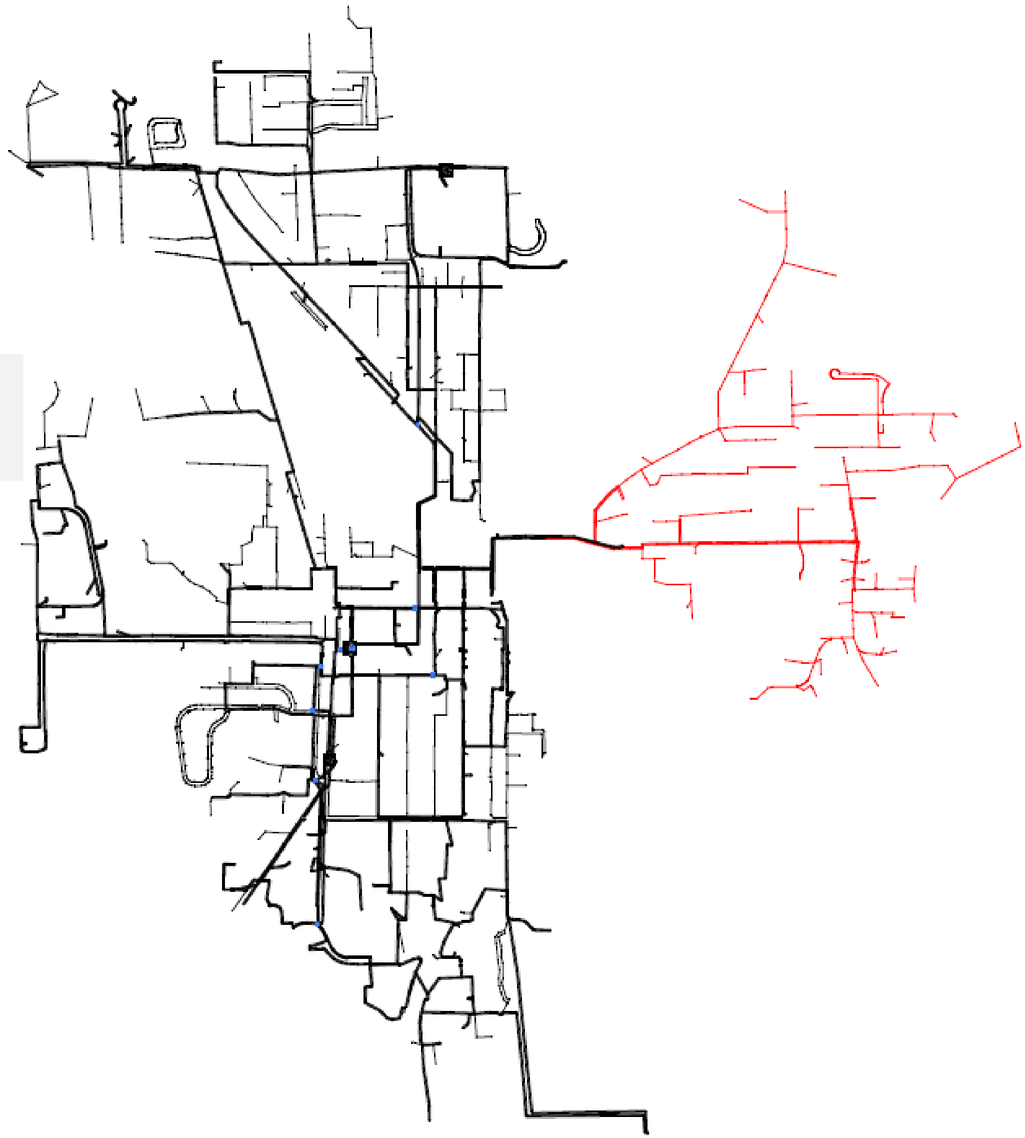
SYSTEM ANALYSIS
EXISTING SYSTEM – COLORED BY FEEDER



SYSTEM ANALYSIS
SYSTEM INTACT– 2021 LOADS

(3.5 Volt Maximum Criteria)

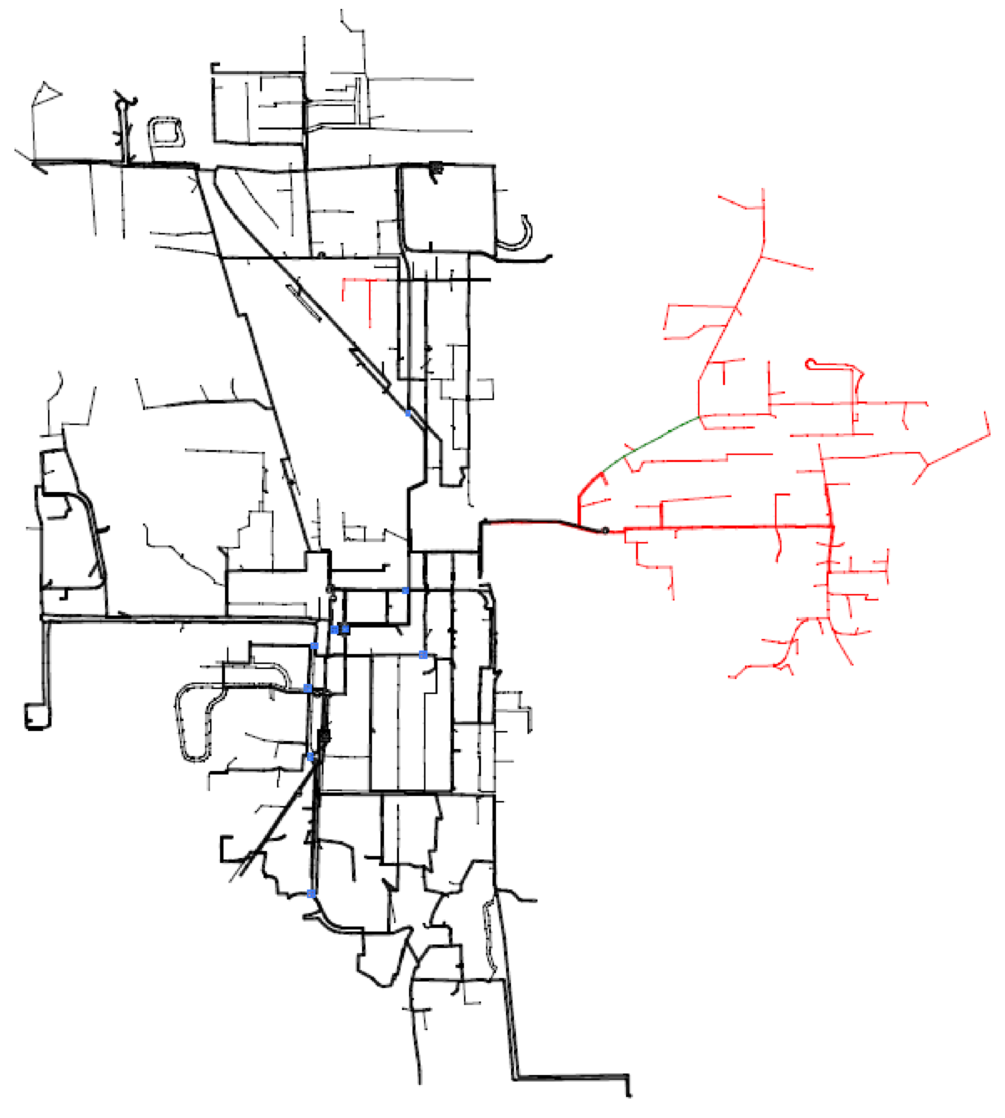
- Feeder 6= 9.9 Volt Drop



SYSTEM ANALYSIS
SYSTEM INTACT– 2031 LOADS

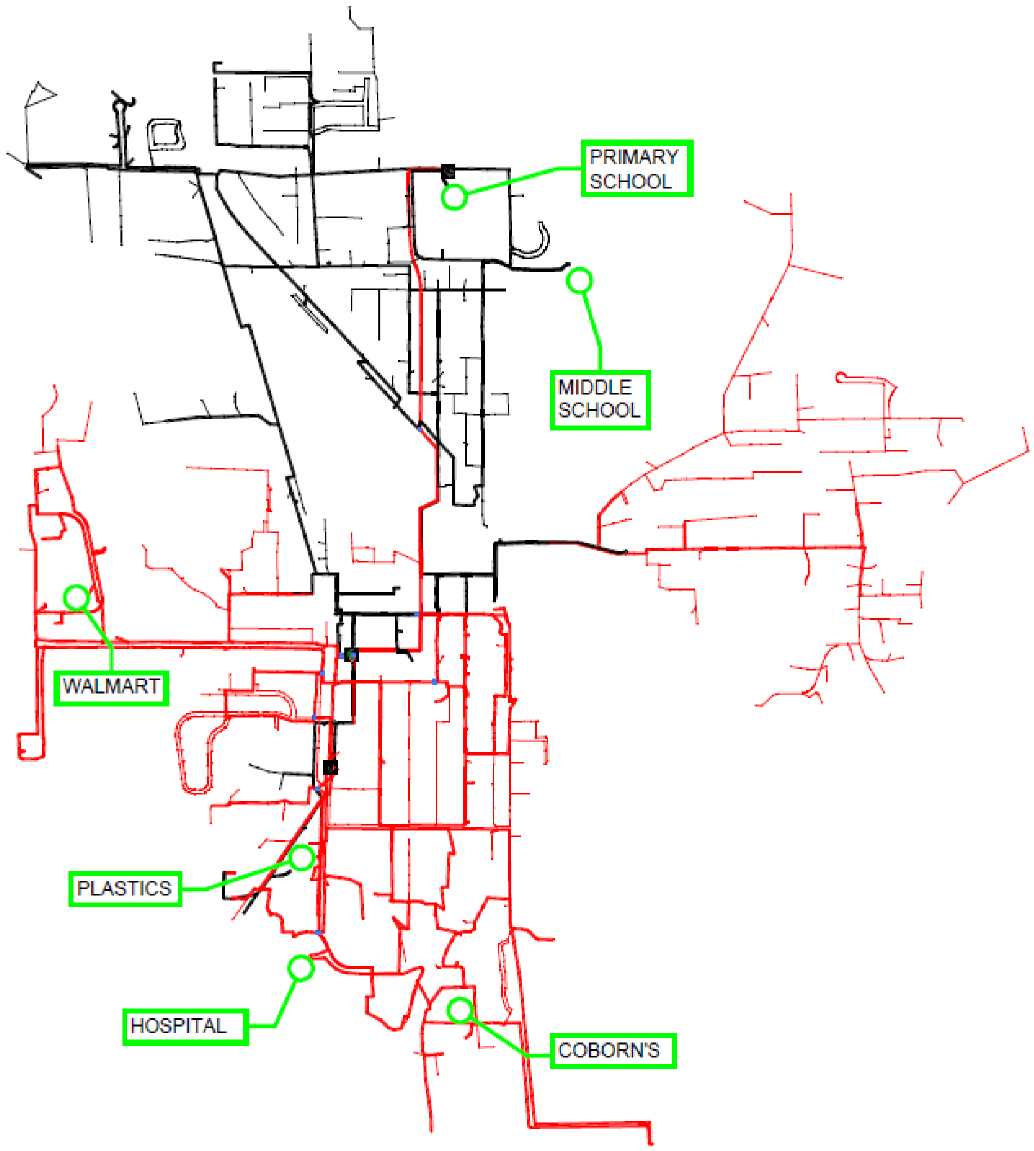
(3.5 Volt Maximum Criteria)

- Feeder 6= 13.4 Volt Drop, 2% Overload



SYSTEM ANALYSIS

LOSS OF SOUTH SUBSTATION 12.47 kV BUS 1 – 2021 LOADS



(3.5 Volt Maximum Criteria)

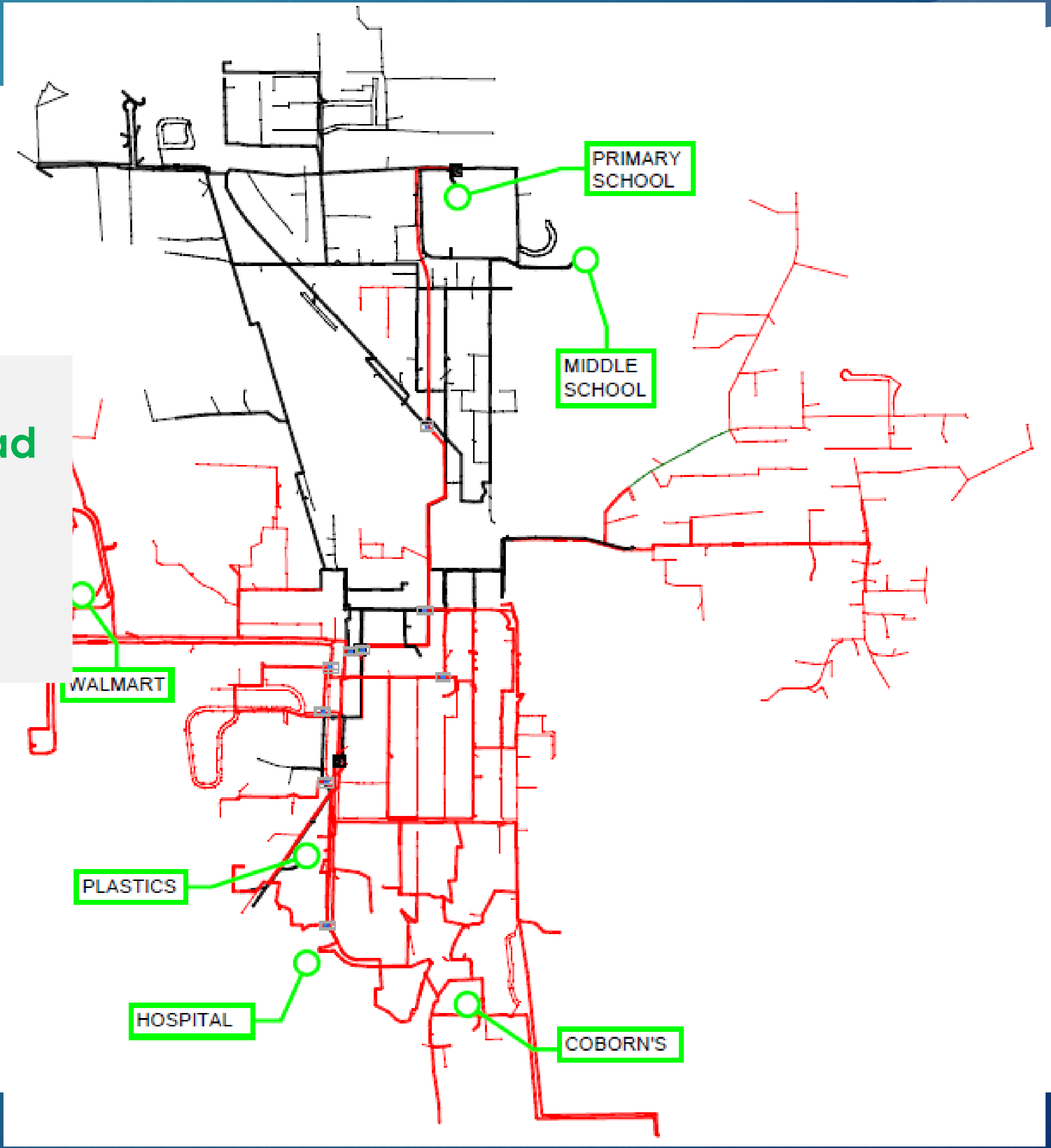
- Feeder 6= 9.9 Volt Drop
- Feeder 12= 6.0 Volt Drop
- Feeder 23= 5.5 Volt Drop
- PP Sub XFMR T1 = 15% Overload
- PP Sub XFMR BT = 13% Overload

SYSTEM ANALYSIS

LOSS OF SOUTH SUBSTATION 12.47 kV BUS 1 – 2031 LOADS

(3.5 Volt Maximum Criteria)

- Feeder 6= 13.4 Volt Drop, 2% Overload
- Feeder 12= 6.7 Volt Drop
- Feeder 23= 6.2 Volt Drop
- PP Sub XFMR T1 = 37% Overload
- PP Sub XFMR BT = 46% Overload

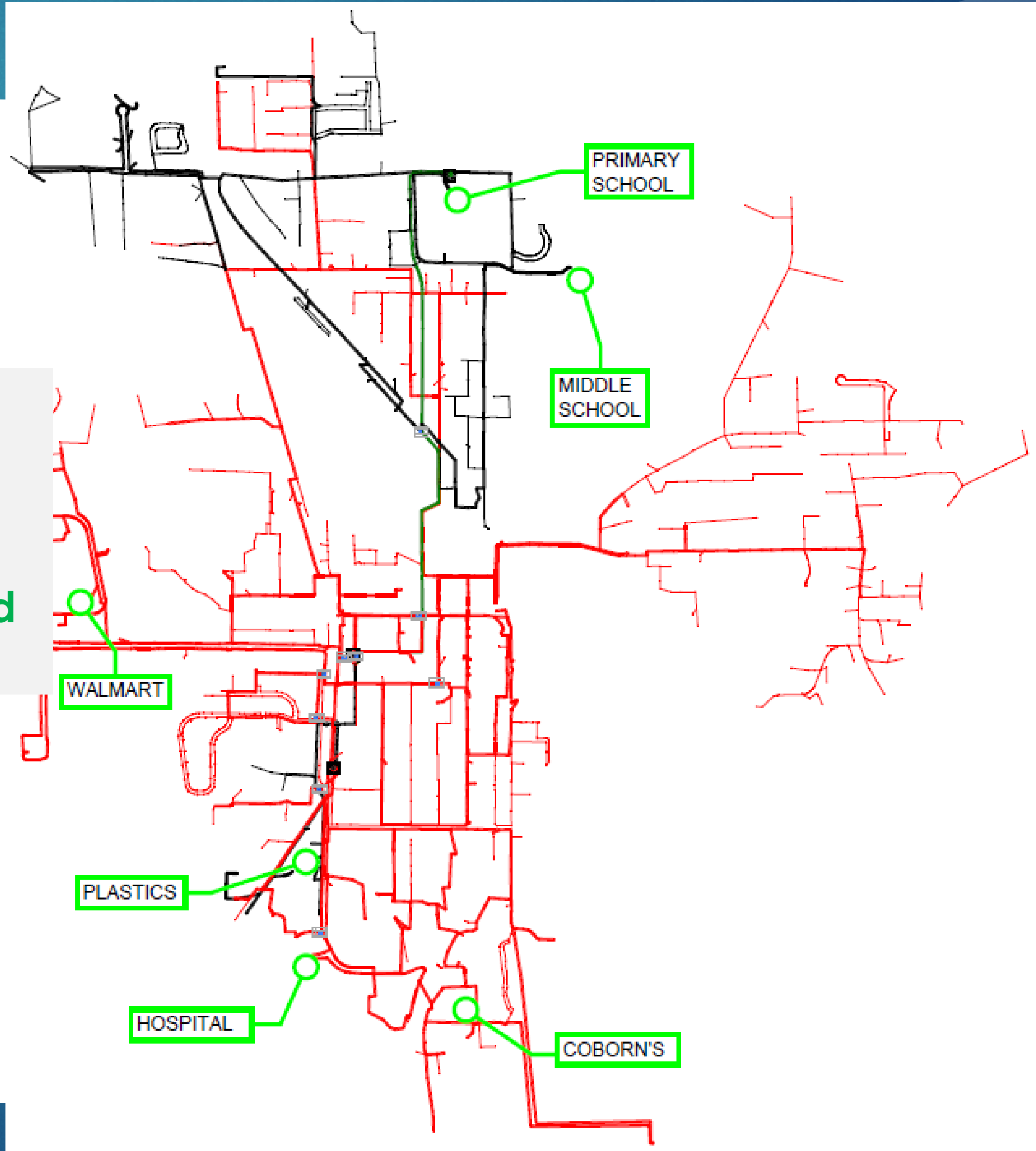


SYSTEM ANALYSIS

LOSS OF SOUTH 69 kV TRANSMISSION LINE – 2021 LOADS

(3.5 Volt Maximum Criteria)

- Feeder 6= 19.2 Volt Drop
- Feeder 12= 8.4 Volt Drop
- Feeder 23= 9.5 Volt Drop
- North Tie= 7.8 Volt Drop, 44% Overload
- North Sub XFMR T2 = 37% Overload

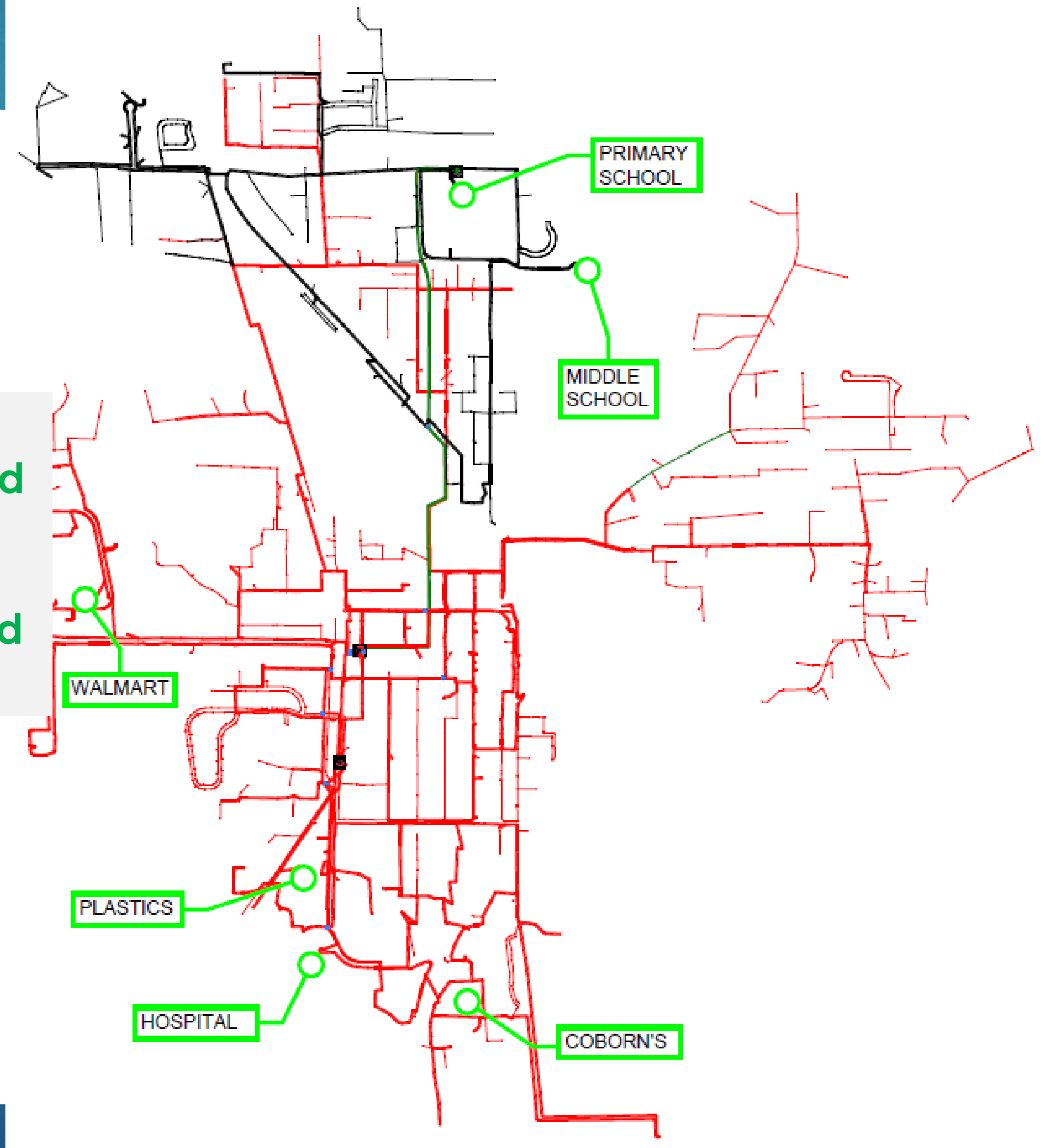


SYSTEM ANALYSIS

LOSS OF SOUTH 69 kV TRANSMISSION LINE – 2031 LOADS

(3.5 Volt Maximum Criteria)

- Feeder 6= 29.8 Volt Drop, 20% Overload
- Feeder 12= 13.9 Volt Drop
- Feeder 23= 15.0 Volt Drop
- North Tie= 13.2 Volt Drop, 80% Overload
- North Sub XFMR T2 = 220% Overload



SYSTEM DEFICIENCIES

- <u>(2) major factors:</u>
  - Age of equipment, useful life
  - Electrical performance (voltage drop, thermal/capacity)

SYSTEM DEFICIENCIES

- <u>69 kV Transmission:</u>
- GRE-Owned North Feed, SMMPA-Owned South Feed
  - No deficiencies noted.
  - Provided adequate reliability to PPU in the past.
  - Appears well-equipped to serve PPU into the future.

SYSTEM DEFICIENCIES

- North Substation:
  - The following equipment is nearing or at the end of its useful life and should be replaced:
    - 67-12.47 kV Power Transformer T1 (~23 years old, offline due to gassing issues)
    - 12.47 kV Switchgear Bus 1 (~56 years old)
    - 12.47 kV Switchgear Bus 2 (~47 years old)
  - The 69 kV fuses that protect the 69-12.47 kV transformer T1 should be replaced with a relayed 69 kV Circuit Interrupter. This will provide better protection and eliminate the possibility of single-phasing customers.

SYSTEM DEFICIENCIES

- Power Plant Substation:
  - The following equipment is nearing or at the end of its useful life and should be replaced:
    - 69 kV Circuit Switcher (~38 years old)
    - 67-4.16 kV Power Transformer T1 (~38 years old – estimated based on Circuit Switcher)

SYSTEM DEFICIENCIES

- 12.47 kV & 4.16 kV Distribution System:
  - Low voltage exists on certain areas of the 4.16 kV primary electric system, even under normal operating conditions. This situation significantly worsens during emergency conditions and becomes more widespread under anticipated future load growth. The system cannot handle anticipated future load growth under normal system operation without poor voltage conditions.
  - The system cannot handle the loss of the South Substation Transformer T1 (12.47 kV) and/or 12.47 kV Bus 1. Voltage deficiencies occur on multiple circuits after backfeeding, and the Power Plant does not have the transformer capacity to serve the added load from the South Substation. This situation will worsen under anticipated future load growth

SYSTEM DEFICIENCIES

- <u>12.47 kV & 4.16 kV Distribution System (Continued):</u>
  - The loss of Power Plant Substation Transformer T1 (4.16 kV) results in worsening voltage conditions on the 4.16 kV system. This situation will worsen under anticipated future load growth.
  - The system cannot handle the loss of the Power Plant 4.16 kV Bus 1. This results in a complete outage on all the 4.16 kV feeders out of the Plant as no backfeeding capabilities exist for these circuits.
  - During a loss of the 69 kV South Transmission line, the existing system experiences major voltage drop issues after backfeeding without the use of generation (potentially long-term). The North Substation Transformer T2 and the 12.47 kV tie between the North Substation and Power Plant become overloaded. This situation will worsen under anticipated future load growth.

SYSTEM DEFICIENCIES

- 12.47 kV & 4.16 kV Distribution System (Continued):
  - 200 amp load-break elbows are used on 4/0 circuit mainlines, which significantly reduces the capacity of the circuit.
  - 200 amp load-break elbows in sectionalizers and primary metering cabinets are used as switching points.
  - Additional 4/0 mainline circuitry, switches, fuses, and circuit ties are needed to increase reliability of the system.
  - Circuits lack adequate sectionalizing. Many circuits do not have adequate fusing such that the outage would include most of the circuit instead of a small portion.

SYSTEM DEFICIENCIES

- 12.47 kV & 4.16 kV Distribution System (Continued):
  - There is a need for more switch ties on the 12.47 kV distribution system between the North Substation and the Power Plant; and between the Power Plant and South Substation.
  - The condition of the 4.16 kV overhead distribution system is poor to average in general and is in need of replacement.
  - Having different distribution system voltages (4.16 kV and 12.47 kV) in town results in reduced reliability since the circuits cannot backfeed one another during an outage condition. In addition, the different voltages require different pieces of equipment and therefore additional inventory. Additionally, conversion of the 4.16 kV system to 12.47 kV will reduce overall system losses, resulting in real cash savings for PPU.

SYSTEM DEFICIENCIES

- Power Plant:
  - The age of the existing older generators at the Power Plant continues to be a concern, specifically the diminishing availability of spare parts and the expertise to work on the units.

SYSTEM DEFICIENCIES

- Miscellaneous:
  - The existing coordination study should be updated to determine correct fuse sizes for better coordination of equipment throughout the system. After the new sizes are implemented, the system will perform better at isolating faults to smaller areas and provide better protection to equipment. Additionally, fuse inventory will be reduced.
  - PPU needs to update the arc-flash study of their electric system to align with recent code and industry changes.
  - In lieu of the digital "scoreboard" at the Power Plant, PPU would benefit from an enhanced SCADA System.

RECOMMENDED IMPROVEMENTS

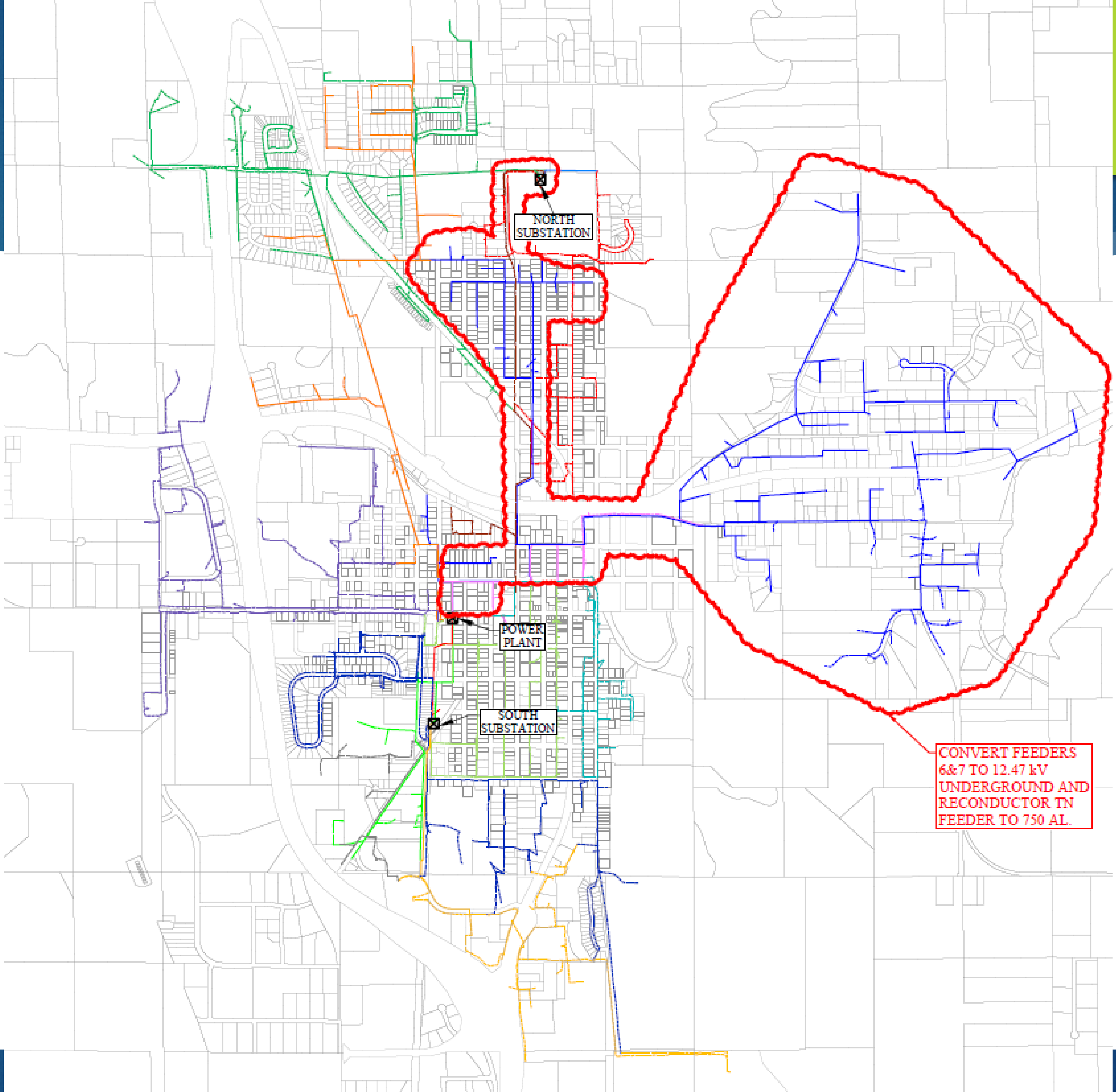
- Why?
  - Eliminate identified deficiencies
  - Equip your electric system to accommodate future load growth projected over the next 10 years
  - Increase system reliability
  - Proactive vs. Reactive

RECOMMENDED IMPROVEMENTS

- Timing is Critical:
  - Due to transformer sizes and reliability, the timing of 4.16 kV conversions versus substation improvements is critical
  - Nail down schedule/timing during preliminary design
- Strengthening the North Substation vs. Relying on Long-Term Generation

PHASE 1 IMPROVEMENTS (2022-2024)

PHASE 1 IMPROVEMENT ITEM	EST. COST
<u>Distribution Improvements:</u>	
4.16 kV Feeders 6 & 7 Conversion	$ 2,542,000
North Substation – Power Plant Tie Reconductor	450,000
Engineering & Contingencies	862,000
Subtotal	**$ 3,854,000**


NORTH SUBSTATION
POWER PLANT
SOUTH SUBSTATION
CONVERT FEEDERS 6&7 TO 12.47 kV UNDERGROUND AND RECONDUCTOR TN FEEDER TO 750 AL.

PHASE 1 IMPROVEMENTS (2022-2024) - Continued

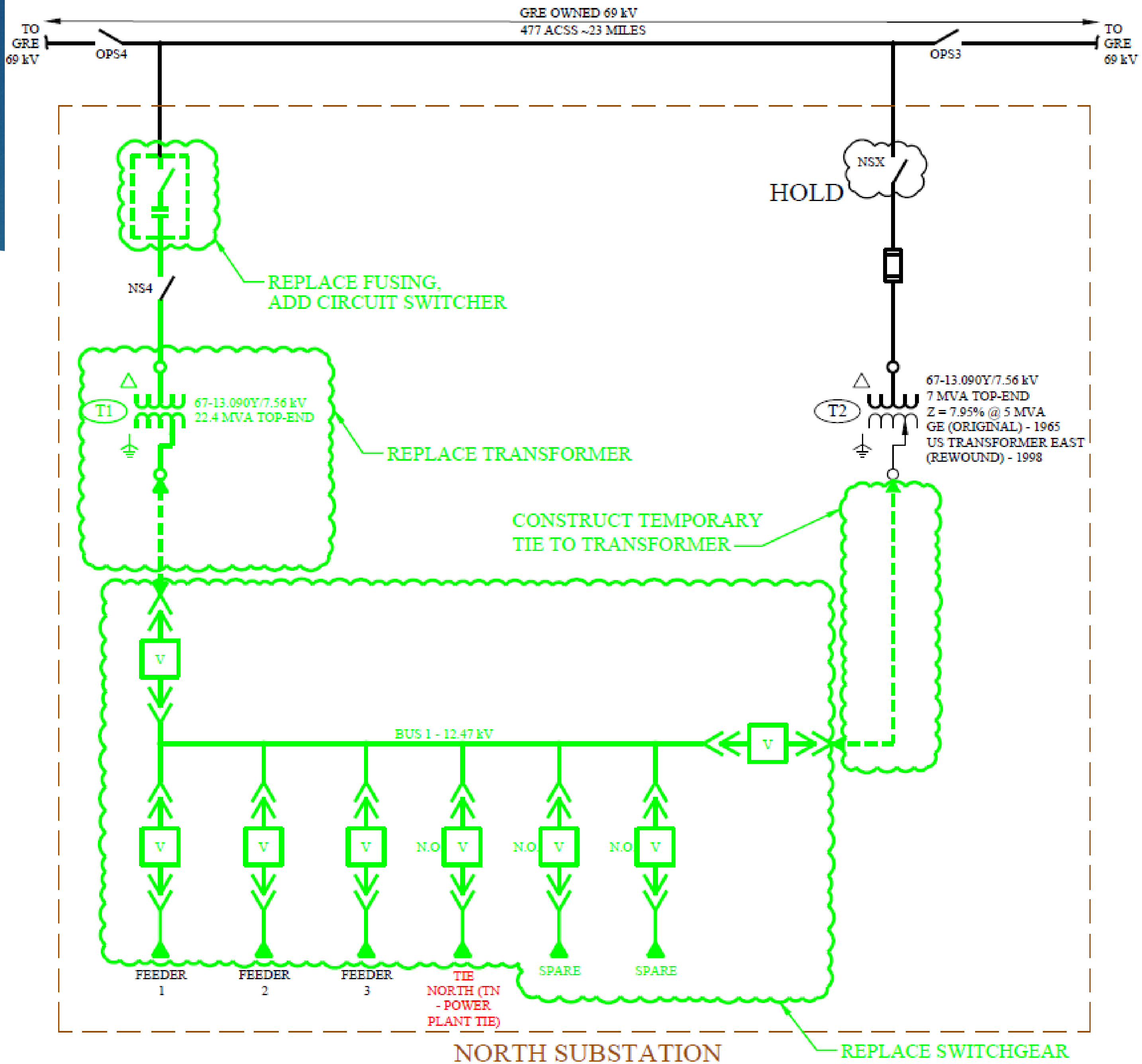
PHASE 1 IMPROVEMENT ITEM	EST. COST
<u>**Miscellaneous System Improvements:**</u>	
Conduct Electric Retail Rate Study	$ 25,000
Conduct Coordination Study	16,000
Conduct Arc Flash Study	25,000
Subtotal	**$ 66,000**

PHASE 1 IMPROVEMENTS (2022-2024) - Continued

PHASE 1 - SUMMARY	EST. COST
Distribution Improvements	$ 3,854,000
Miscellaneous System Improvements	66,000
TOTAL – PHASE 1	**$ 3,920,000**

PHASE 2 IMPROVEMENTS (2024-2027)

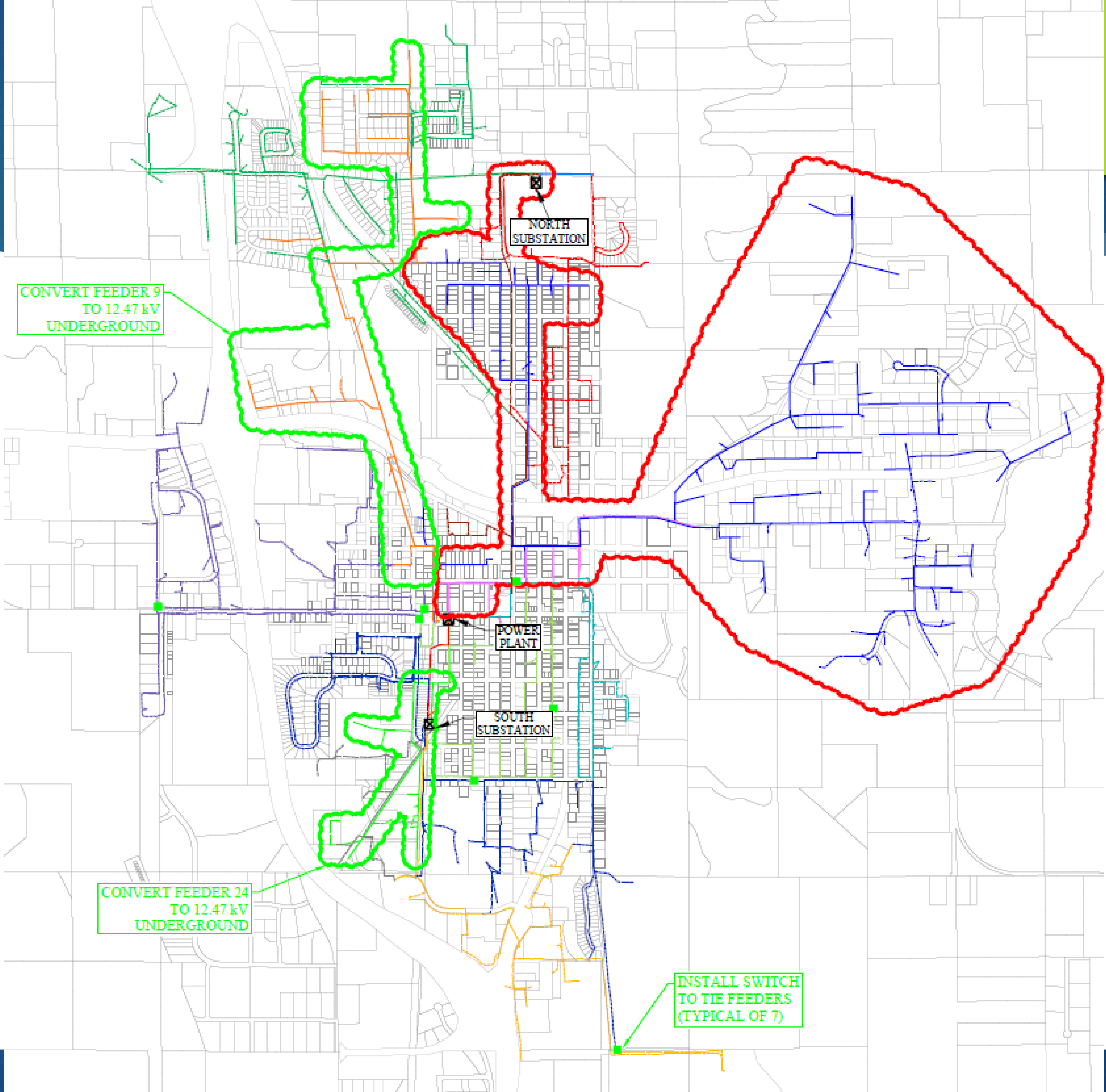
PHASE 2 IMPROVEMENT ITEM	EST. COST
North Substation Improvements:	
69 kV Circuit Switcher, Steel	$ 81,300
69-12.47 kV Power Transformer, 22.4 MVA	1,100,000
15 kV Switchgear (1M, 6F, 1BT)	490,000
Construction, Miscellaneous	479,500
Engineering & Contingencies	619,400
Subtotal	**$ 2,770,200**



GRE OWNED 69 kV
477 ACSS ~23 MILES
TO GRE 69 kV
OPS4
OPS3
TO GRE 69 kV
NSX
HOLD
REPLACE FUSING, ADD CIRCUIT SWITCHER
NS4
T1
67-13.090Y/7.56 kV
22.4 MVA TOP-END
REPLACE TRANSFORMER
T2
67-13.090Y/7.56 kV
7 MVA TOP-END
Z = 7.95% @ 5 MVA
GE (ORIGINAL) - 1965
US TRANSFORMER EAST
(REWOUND) - 1998
CONSTRUCT TEMPORARY TIE TO TRANSFORMER
BUS 1 - 12.47 kV
V
N.O
FEEDER 1
FEEDER 2
FEEDER 3
TIE NORTH (TN - POWER PLANT TIE)
SPARE
SPARE
NORTH SUBSTATION
REPLACE SWITCHGEAR

PHASE 2 IMPROVEMENTS (2024-2027) - Continued

PHASE 2 IMPROVEMENT ITEM	EST. COST
Distribution Improvements:	
4.16 kV Feeder 9 Conversion	$ 1,307,000
4.16 kV Feeder 24 Conversion	307,000
Miscellaneous Circuit Ties	215,000
Engineering & Contingencies	526,000
Subtotal	**$ 2,355,000**

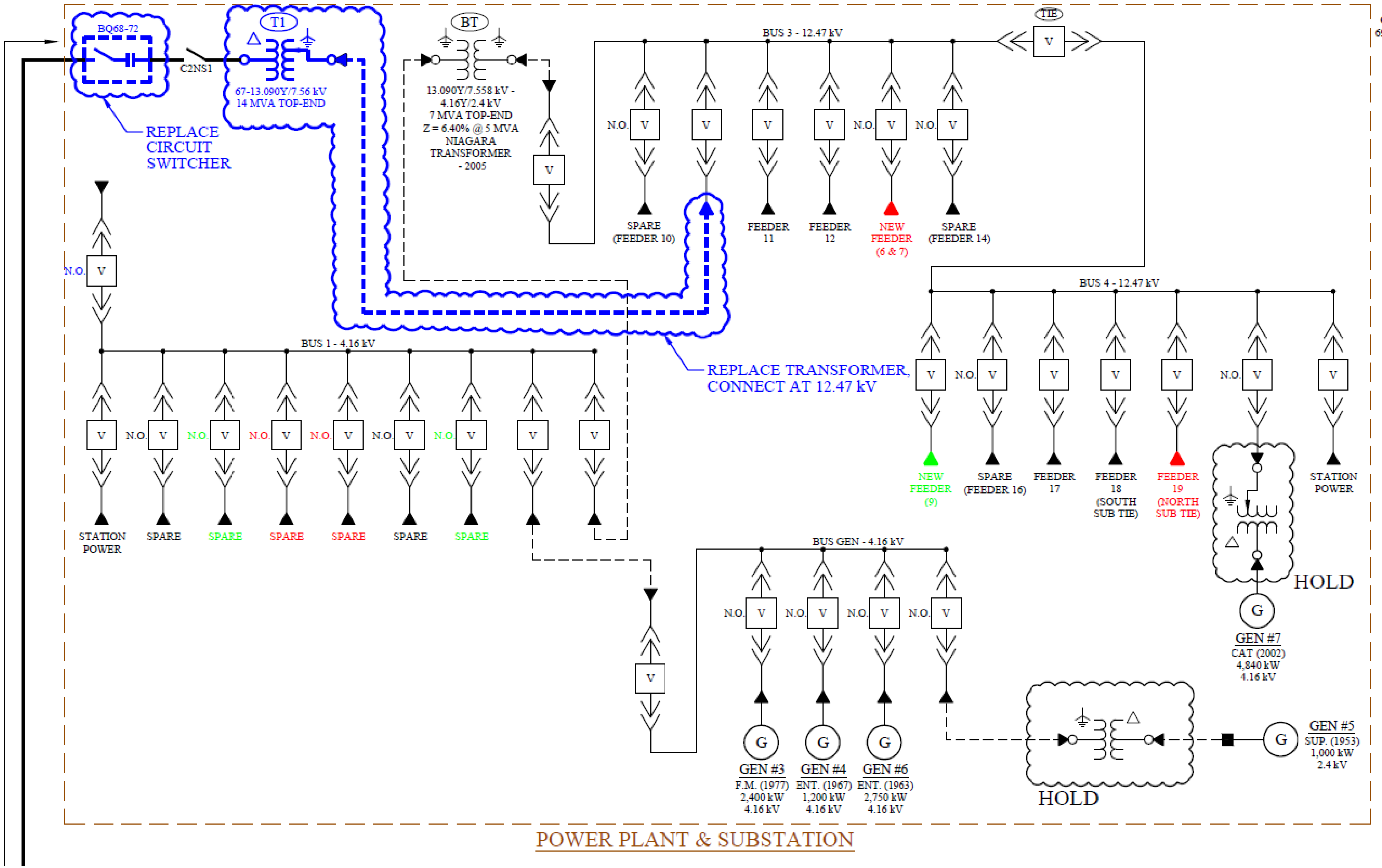

NORTH SUBSTATION
CONVERT FEEDER 9 TO 12.47 kV UNDERGROUND
POWER PLANT
SOUTH SUBSTATION
CONVERT FEEDER 24 TO 12.47 kV UNDERGROUND
INSTALL SWITCH TO TIE FEEDERS (TYPICAL OF 7)

PHASE 2 IMPROVEMENTS (2024-2027) - Continued

PHASE 2 – SUMMARY	EST. COST
North Substation Improvements	$ 2,770,200
Distribution Improvements	2,355,000
TOTAL – PHASE 2	**$ 5,125,200**

PHASE 3 IMPROVEMENTS (2027-2030)

PHASE 3 IMPROVEMENT ITEM	EST. COST
Power Plant Substation Improvements:	
69 kV Circuit Switcher, Steel	$ 81,300
69-12.47 kV Power Transformer, 14 MVA	850,000
69 kV Control Panel	50,000
Construction, Miscellaneous	472,500
Engineering & Contingencies	418,700
Subtotal	**$ 1,872,500**



POWER PLANT & SUBSTATION

PHASE 3 IMPROVEMENTS (2027-2030) - Continued

PHASE 3 IMPROVEMENT ITEM	EST. COST
SCADA System Development:	
Hardware and Software	$ 100,000
Communications Link	250,000
Facilities Integration	220,000
Engineering & Contingencies	182,400
Subtotal	**$ 752,400**

PHASE 2 IMPROVEMENTS (2027-2030) - Continued

PHASE 3 – SUMMARY	EST. COST
Power Plant Substation Improvements	$ 1,872,500
SCADA System Development	752,400
TOTAL – PHASE 3	**$ 2,624,900**

COST ESTIMATE SUMMARY CAPITAL IMPROVEMENTS PLAN

CIP PHASES – 10 YEAR OUTLOOK	EST. COST
Phase 1 (2022 – 2024)	$ 3,920,000
Phase 2 (2024 – 2027)	$ 5,125,200
Phase 3 (2027 – 2030)	$ 2,624,900
TOTAL CIP Cost	**$ 11,670,100**

HOW DO WE PAY FOR IT?

- <u>Need funds for projects:</u>
  - Initial Financial Planning as part of Rate Study:
    - Establish revenue requirements
    - Coordinate with financial advisors/bonding agent
    - Determine potential impacts to rates

RECOMMENDED NEXT STEPS

- <u>**Authorize Design Services for Phase 1:**</u>
  - Preliminary Design Efforts for Distribution Improvements Project:
    - Circuit Diagrams
    - Project Schedules
    - Update Cost Estimates
    - Cash Flows for Coordination w/Financial Advisors
  - Coordination & Arc Flash Studies

RECOMMENDED NEXT STEPS

- **Authorize Design Services for Phase 1 (ctd.):**
  - Rate Study, Analysis of Financial Situation:
    - Coordinate with Financial Advisors/Bonding Agent
    - Examine Impact to Rates
    - Make Recommendations to the Commission
  - Having a great team with municipal experience is critical
  - Present Task Orders for Phase 1 for Consideration by Commission at January meeting?

QUESTIONS?

Thank you!

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